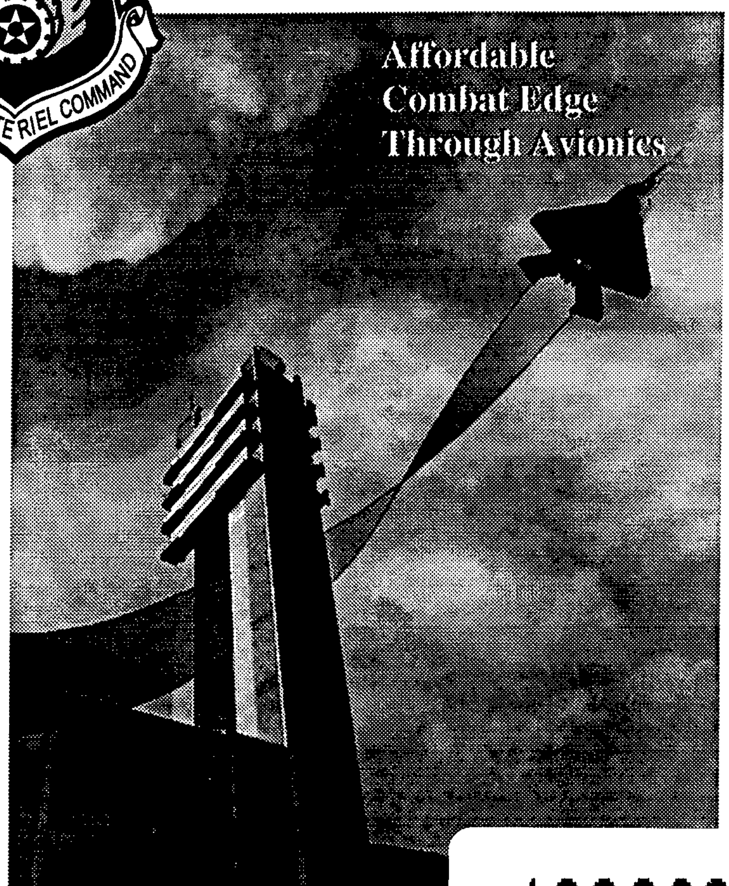
FY98
AVIONICS
TECHNOLOGY AREA PLAN



AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AFB, OH

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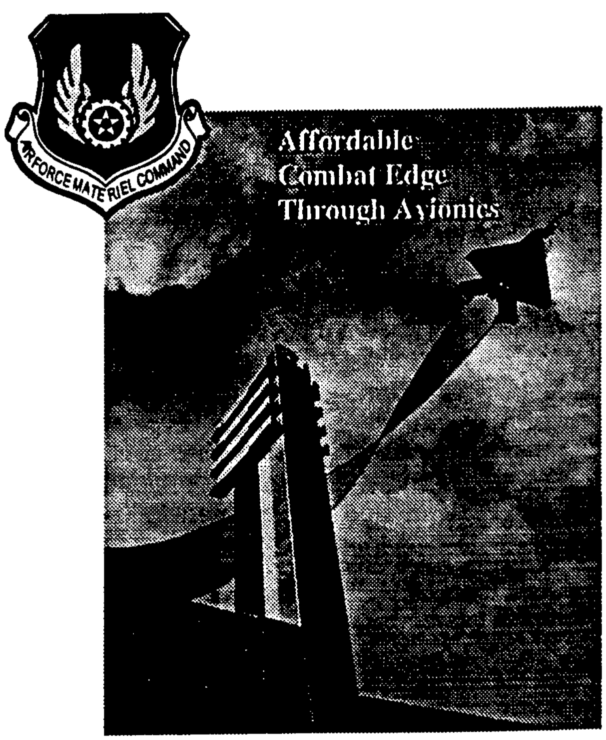

The Avionics Directorate is providing national leadership in the transformation from legacy federated avionics to more affordable and supportable, open-architecture integrated avionics for the future. The adopted icon for this avionics revolution is the "transformation arrow" as illustrated on the following page. Pictured with the Dayton area landmark avionics tower facility is a maneuvering aircraft—replicating this transformation theme.

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On 15 February 1996, HQ USAF approved the merger of Wright Laboratory's Solid State Electronics and Avionics Directorates. This "re-engineering" of the organizational structure for avionics technology development was pursued as one of three critical elements in the overall strategy for achievement of the Air Force vision for 21st Century Avionics. A second element in this strategy is the consolidation of widely scattered facilities into a flexible teaming environment for integrated "system level" technology development and evaluation. The third element involves the refocusing of Avionics technology investment into a limited number of high payoff areas which address the most critical avionics and airborne information needs of the war fighter in the 21st Century.

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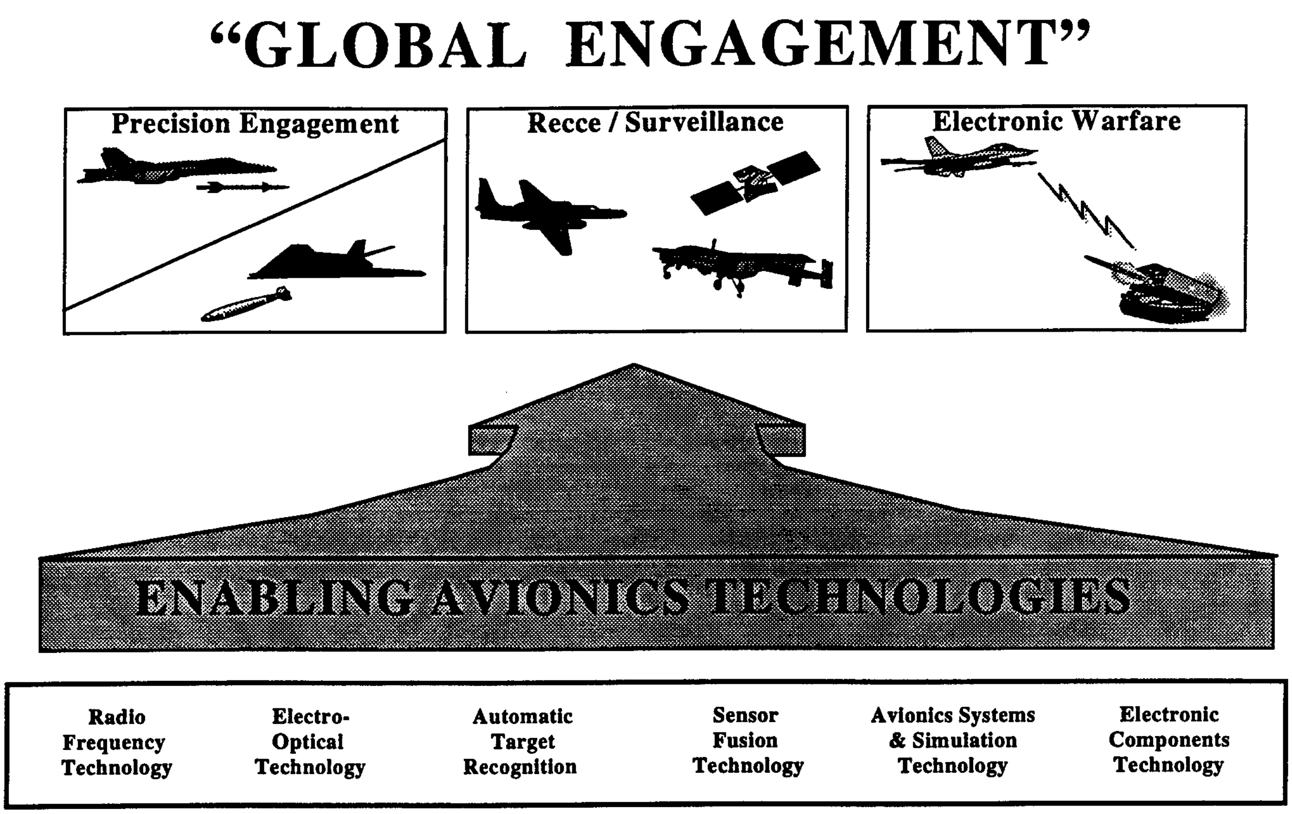


VISIONS AND OPPORTUNITIES

Global Engagement: A Vision for the 21st Century Air Force outlines the air and space core competencies which support the national security strategy, the successful pursuit of which requires the continued superiority of our aerospace systems. The widening variety of Air Force missions challenges these systems to be increasingly flexible, timely, and precise in their application. Wright Laboratory's Avionics Directorate is meeting this modernization challenge:

Developing affordable avionics technology for superior global awareness, precision engagement, and full dimensional protection for America's air and space forces.

More than just an assortment of electronic components and "black boxes," *avionics* for air and space platforms includes active and passive sensors for assessing the local situation, reference systems for space-time context for all combatants, on-board computation for threat identification, response and weapon fire control, and the communication node with the rest of the global engagement infrastructure. The picture above illustrates the central role of avionics functions and enabling avionics technologies in the "system-of-systems" and Global Engagement visions. Assured and superior performance of these critical military functions is the only objective of the avionics technology investment strategy—providing the critical airborne and space elements for Full Spectrum Dominance.

The Avionics Directorate is committed and well positioned to continue its long-standing role as developer of core avionics technology for a variety of recce/surveillance, C^{4}I, and combat systems. Its current challenge is to apply militarily unique and commercial technologies to accomplish the transformation of legacy "closed architecture" systems to more affordable and flexible "open architecture" systems. Extending this philosophy to all air and space "players" enhances the potential for the interoperability needed for superior performance and reduced life cycle cost for the integrated "system-of-systems."

Avionics Technologies are Key Enablers for Air Force Core Competencies

The *Global Engagement* vision is supported by six core competencies representing the Air Force contribution to the Joint Force Team. Critical avionics technology needs of the war fighters are listed with each:

Air and Space Superiority—providing joint force commanders freedom from attack as well as freedom to attack; technology to find, track, and target anything—dominating enemy operations in all dimensions.

- Non-Cooperative Target Identification
- Long Range Threat Detection Sensors
- Air-to-Air Fire Control
- High Performance Sensor Components

Global Attack—attack anywhere, anytime—quickly and with precision in spite of natural (weather) or threat environments.

- Foliage Penetration Radar
- Counter CC&D Multi-Spectral Sensors
- Precision Threat Identification & Location
- Threat Countermeasures

Rapid Global Mobility—timely, responsive support to a widening variety of contingency operations involving multi-national teams and adverse environments.

- Situation Awareness / Threat Alert
- Large Aircraft Infrared Countermeasures
- Real-Time Threat Avoidance

Precision Engagement—timely, precise and reliable application of military force with minimal risk and collateral damage.

- "Ballistic Winds"
- Automatic Target Recognition
- RTIC/RTOC
- Air-to-Ground Fire Control

Information Superiority—integrated and seamless information collection and exploitation for battle space awareness and response execution.

- LPI / LPE Communication
- Information Fusion
- Assured Space-Time Reference Systems
- Command & Control Warfare
- High Performance Communication Components

Agile Combat Support—efficient force deployment and sustainment reflecting agile and responsive "fixes" to equipment deficiencies within the context of "lean logistics."

- Aging Avionics Initiative—Low Cost Replacements
- Legacy System Software Upgrades
- On-Line User Support to Counter New Threat Systems
- Open Hardware & Software System Architectures
- Collaborative Engineering Environment Supporting Rapid Technology Insertion & War fighter's CONOPS Development

The Bottom Line

To meet future mission objectives, the war fighter must become an active participant in the military information infrastructure—continuously aware of the combat situation and adapting the response to new information. Only with avionics does the war fighter obtain the information needed by air and space platforms to achieve this "system-of-systems" vision. Investment in avionics technology will assure that this vision, as well as current war fighting needs, can be achieved affordably.

This plan has been reviewed by all Air Force Laboratory Commanders/Directors and reflects integrated Air Force Technology Planning. We request Air Force Acquisition Executive approval of this plan.

RICHARD W. DAVIS, Colonel, USAF
Commander
Wright Laboratory

RICHARD R. PAUL
Major General, USAF
Technology Executive Officer

CONTENTS

INTRODUCTION

On 15 February 1996, HQ USAF approved the merger of Wright Laboratory's Solid State Electronics and Avionics Directorates. This "re-engineering" of the organizational structure for avionics technology development was pursued as one of three critical elements in the overall strategy for achievement of the Air Force vision for 21st Century Avionics. A second element in this strategy is the consolidation of widely scattered facilities into a flexible teaming environment for integrated "system level" technology development and evaluation. The third element involves the refocusing of Avionics technology investment into a limited number of high payoff areas which address the most critical avionics and airborne information needs of the war fighter in the 21st Century. These new "focus areas" include:

- Affordable, Precision Offensive/Defensive Sensors for Airborne and Space-Based Operations
- Sensor-to-Shooter Information for Global Engagement
- Rapid Technology Integration for System Design, Development, Evaluation, Training and Support
- Affordable, High Performance Militarily Unique Devices Enabling Battlespace Dominance

As Figure 1 illustrates, air and space platforms operating in complex "system-of-systems" environments must perform a multitude of information functions to assure situational awareness and battlespace dominance. The overall objective of the investment described in this plan is to develop and transition the technologies to accomplish a transformation of legacy "closed architecture" systems to more affordable, flexible, and capable "open architecture" systems.

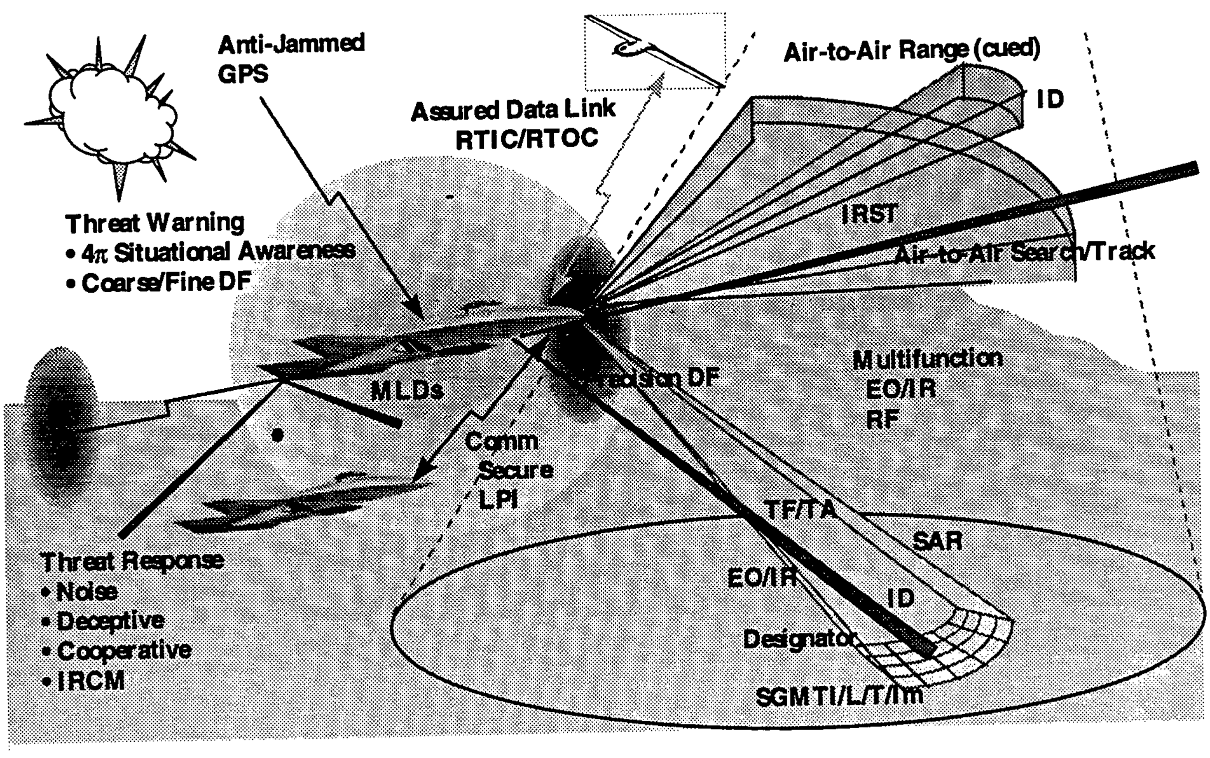
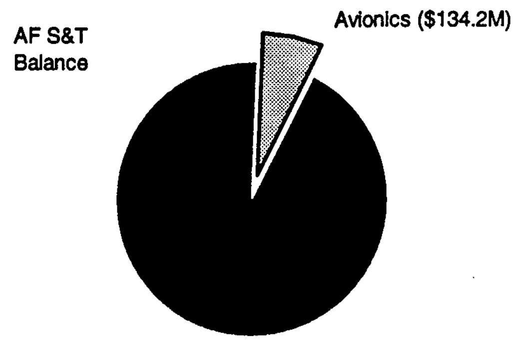


Figure 1: Affordable, Precision Offensive/Defensive Sensors for Global Engagement

BACKGROUND

The Avionics Technology Area, highlighted in Figure 2, is that part of the Air Force Science and Technology (S&T) Program charged with providing avionics and electronics to support all Air Force mission areas. The avionics program promotes the development of alternatives for future mission requirements and near-term weapon system upgrades to current assets. It emphasizes a balance between performance, availability, and affordability. It develops the basic microelectronics, microwave, and electro-optical devices and components, as well as the offensive and defensive avionics system and subsystem and avionics architecture technologies for aerospace vehicles.

Avionics accounts for 11.1 percent of the Air Force FY98 S&T budget as shown in Figure 3.



ESTIMATED AF S&T BUDGET FOR FY98: $1.2B

Figure 3: Avionics S&T vs. AF S&T

Funding reflects the President's Budget Request and may change based on possible congressional action.

The total FY98 funding for this area is estimated at $261M with S&T funds amounting to

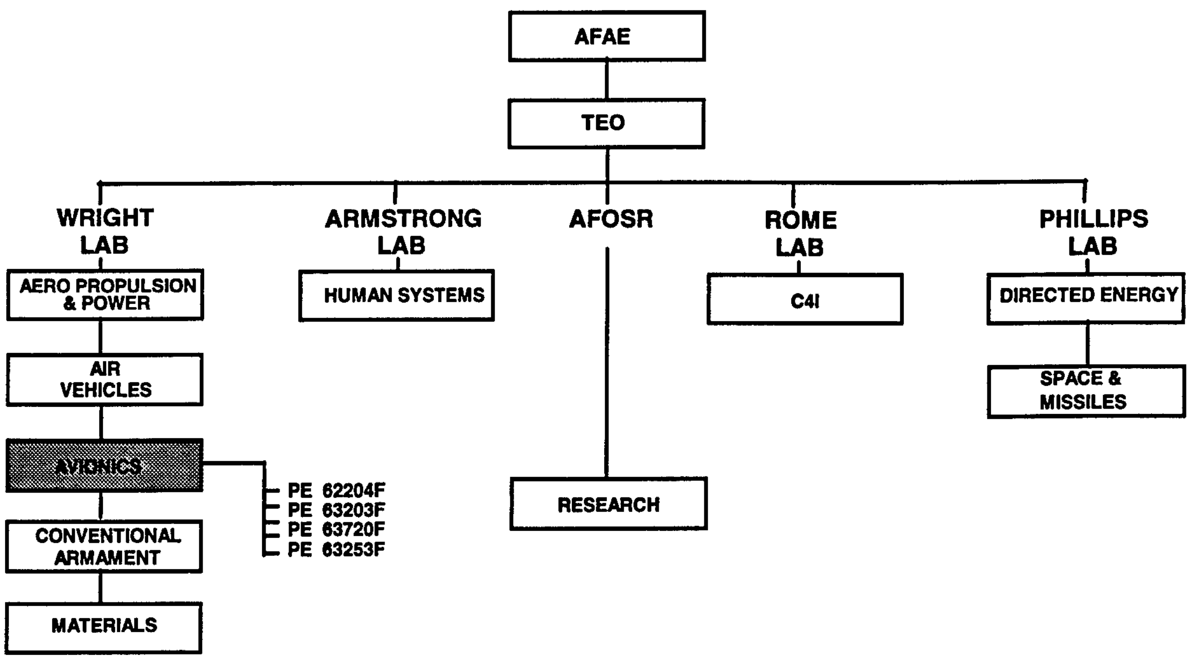


Figure 2: Air Force S&T Program Structure

about 51 percent of this total. The Defense Advanced Research Projects Agency (DARPA) provides the largest single source of non-AF S&T funding (about 40 percent) primarily in the areas of High Temperature Superconductivity, Computer Aided Design and Rapid Prototyping, High Density Microwave Packaging, and Information Processing. About 4 percent of the funds come from the 6.3B Air Combat Command (ACC) sponsored Combat Identification Technology Program Element (PE) for work on non-cooperative target identification.

The recently established Air Force Modernization Planning Process (MPP) and Technology Master Process (TMP) have intensified planning with Major Commands (MAJCOMS), System Program Offices (SPOs), and industry. Advanced development efforts in the Avionics Technology Area Plan (TAP) continue to be highly rated by the MAJCOMs and Product Center users for relevancy and by the Air Force Scientific Advisory Board (SAB) for technical quality. This indicates that we are attaining a good balance of supporting the users while maintaining technical excellence. MAJCOMs are demonstrating interest and commitment by budgeting early for transition of our key programs.

The Avionics Technology programs are developed from a comprehensive investigation of future Air Force capability needs and the need to continue to enhance our technical superiority at an affordable cost. The challenge is to focus avionics resources into areas that can achieve the greatest increase in combat capability along with providing corresponding improvements in affordability, reliability, and maintainability. Engineers and scientists work closely with HQ Air Force Materiel Command (AFMC), AFMC Product Center Development Planning communities, SPOs, and MAJCOM to identify capability needs.

Inputs considered in preparing this integrated plan are the Technology Needs and User Reviews. The Air Force Acquisition Executive (AFAE) provides annual guidance, and the SAB provides yearly technical guidance. Inputs from industry, academia, and Air Force/ Service/ Agency Laboratories were also considered in developing the plan.

Cooperation with the user is being further enhanced by a teaming process that formalizes and improves the documentation of users' present and projected future capability deficiencies and their plans for rectifying those deficiencies in Mission Area Plans (MAPs).

The Technical Planning Integrated Product Teams (TPIPTs), co-chaired by Product Centers and MAJCOMs and include membership from all AF Laboratories, SPOs, XRs, and Development Planning members, link the users' deficiencies with the Laboratory programs to resolve the MAJCOM mission area deficiencies.

Project Reliance resulted in a significant increase in inter-AF laboratory and interservice coordination. The Avionics Directorate is currently supporting the JSF program by providing engineering and program management expertise. The JSF program is developing the next generation of strike fighter for the Air Force, Navy, and Marines. and has completed its Concept Exploration phase. The degree of service commonality varies between 70% and 90% with individual designs bringing with it the cost benefits of a common depot, commonly supported logistics trail, and increased joint service interoperability. The program has entered the Concept Development phase. The primary emphasis of this phase is to develop aircraft system designs that take advantage of the "family of aircraft" concept and to define the necessary leveraging technology demonstrations and an integrated plan for conducting the follow-on Concept Demonstration phase.

Currently, national goals and priorities for S&T are defined and coordinated by DoD, NASA, and industry through the Air Force Modernization Planning Process and the DoD Defense Technology Area Plans (DTAPs). Goals and programs within the DTAPs have been established to solve technical problems leading to affordable future avionics. To achieve these goals, the Avionics TAP is aligned with the Air Force TPIPTs; MAPs and four DTAP technology areas. Specifically, the Avionics TAP is aligned with the DTAP technology subareas: Human Systems Interface (Human Systems); Computing/Software and Modeling/Simulation (Information Systems and Technology); Sensors, Electronics, and Battlespace Environments (Sensors and Electronics); and Electronic Warfare and Directed Energy (Weapons). The Avionics intersections with the DTAPs are shown in Figure 4.

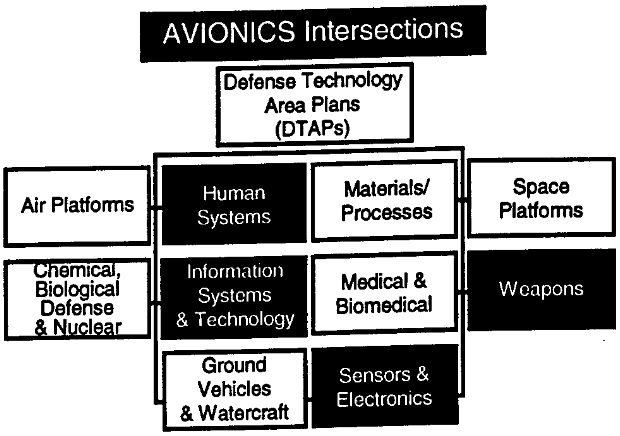


Figure 4: DoD Defense Technology Area Plan

The Avionics TAP encompasses four main business areas as listed in Table 1.

Table 1: Major Avionics Technology Thrusts

1. Targeting and Attack Avionics
2. Electronic Warfare Technology
3. System Avionics
4. Military Unique Electron Devices

The relative emphasis of these thrusts is shown by the distribution of the Air Force S&T funds in Figure 5.

The ultimate vision for military avionics is an avionics suite, supporting offensive and defensive functions, which is easily adapted for the specifics of the mission to be performed. This requires near real-time situation awareness enabling a superior integrated offensive/defensive threat response. The affordable achievement of this combat edge is made possible by information fusion and open architecture integrated avionics.

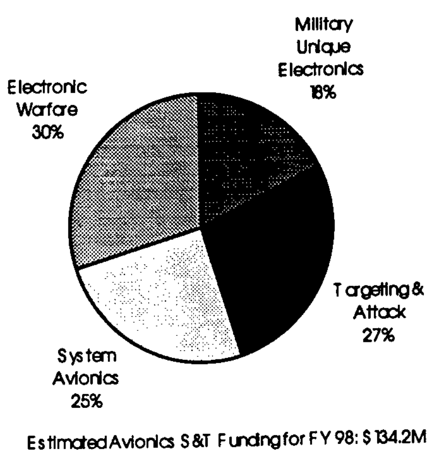


Figure 5: Major Technology Thrusts

RELATIONSHIP TO OTHER TECHNOLOGY PROGRAMS

Industrial Programs - Avionics ranks as one of the highest areas of interest to industry and therefore AA remains actively involved in influencing industry's billion dollar IR&D Program to find solutions to many of its future requirements. This continues to be a valuable complement to the Air Force S&T program. Both public and controlled sites on the World Wide Web are being used to an ever increasing extent for the exchange of information between the Air Force and industry. The web site makes documents such as TAPs, Technology Roadmaps, Mission Need Statements and R&D Descriptive Summaries available to qualified industry users which now includes almost every major DOD contractor. A large majority of these contractors are now submitting their IR&D plans to the DTIC data base for easy access by DOD agencies.

The second Joint Service (Air Force, Army and Navy) Avionics S&T Briefing to Industry (BTI) was held 7-9 May 1997 at Soloman Island MD . The goal was to enhance the working relationship of the Government and Industrial Avionics R&D teams by (a) providing a focus for increased IR&D efforts on Avionics Related programs, (b) encouraging an exchange of information between Government and Industry and (c) providing insight into the Air Force, Army, and Navy's technology programs and goals.

The Avionics Technology area participates in the Small Business Innovation Research (SBIR) program. This program is a valuable source of new ideas and approaches. This year, 41 Phase I efforts and 17 Phase II efforts have been awarded. In support of the Federal Technology Transfer Act, Wright Laboratory's Office of Research and Technology Applications (ORTA) facilitates the transfer of technology between government and industry. Each year, this office coordinates nearly 200 requests for technology transfer information, many of which concern avionics and electronics. The Avionics Directorate has taken an active role in working with industry, academia, and the Wright Technology Network (WTN) in seeking commercial applications of military technology. We have 10 (of Wright Laboratory's 62) currently active Cooperative R&D Agreements (CRDAs). We are "agents" for

several ARPA Technology Reinvestment Project (TRP) efforts. These efforts include the use of fiber optics for video distribution aboard commercial aircraft and the use of high speed digital signal processing for military intercept receivers and commercial telecommunications.

International Programs - The Avionics Directorate benefits from Data Exchange Agreements (DEAs) and Memorandums of Understanding (MOUs) with foreign countries. There are 14 agreements for information exchange and cooperative research between the Air Force and other nations. In the System Avionics area, Nunn Amendment monies and foreign source monies have been used for Allied Standard Avionics Architecture activities. The Electronic Warfare Thrust continues to benefit from several international cooperative ventures that range from data/information exchange to cooperative studies and data analysis; to joint testing of EW techniques and hardware.

Relationship to Other AF TAPS - The Avionics Technology area relates to many of the other S&T Technology Areas.

The Avionics TAP interfaces closely with Air Vehicle Flight Control, Flight Dynamics Integration, and Crewstation Integration thrusts. Joint programs are being pursued between Targeting and Attack and Conventional Armament Advanced Guidance thrusts. Memorandums of Agreement (MOAs) have been established detailing these cooperative agreements. The Avionics Directorate is working closely with Rome Laboratory (RL) on Real-Time Information in the Cockpit (RTIC) programs and also in the area of Information Dominance. The Displays Branch in the Avionics Directorate develops displays technologies which are evaluated by a sister branch in the Command & Control Directorate at RL for C4I applications.

As part of the Collaborative Engineering Environment initiative AA is working with RL to integrate existing multi-lab information infrastructure assets into a representative and demonstratable global awareness network -- New World Vistas Global Awareness Virtual Testbed In addition, AA is working to link its facilities with ESC to unite the RL/ESC C4I expertise with AA's aeronautical experience for "system of systems" evaluations. The advent of low observable threats has motivated Wright and Rome Labs continuing coordination/cooperation in the development of radar terrain scattered jamming interference and ground clutter space-time adaptive processing (STAP) suppression techniques.

Additional relationships with the C4I TAP include a program with RL/OC and the TPS-75 Program Office where AA is leading a joint effort to develop solid state power amplifiers to upgrade the TPS-75 Air Defense Radar.

AA, RL/OC, and the E-3 SPO are working together to develop an advanced klystron transmitter for AWACS. The broadband klystron will have greater reliability at a greatly reduced cost compared to present tubes in operational systems.

Avionics Displays are also reported in the Advanced Cockpit Technology Thrust of the Air Vehicles TAP. The thrust is managed by the Joint Cockpit Office on behalf of the Wright Laboratory and includes hardware and humanware program components in both the Avionics and Flight Dynamics Directorates. This interdirectorate Advanced Cockpit Technology Thrust comprises both the Avionic Displays Subthrust from the Avionics Directorate and the Pilot Vehicle Interface Subthrust from the Flight Dynamics Directorate. This multi-disciplinary approach insures concerted development of workable advanced cockpit technology for pilots and mission crew members. The Avionics Displays work reported therein represents the critical Avionics system interface with the operator.

The Military Unique Electron Devices thrust is coordinated with the Materials and Processing TAP in the areas of materials and processing for microwave and microelectronics applications and non-linear optical materials. Close coordination and joint activities exist in all Communications, Command, Control and Intelligence (C^3I) thrust areas. The relationships to these C^3I areas are addressed in a number of MOAs covering the areas of radar/Electro-Optical; Infrared (EO-IR) detection and tracking; Communications, Command, and Control (C^3) countermeasures; electronic technology; and artificial intelligence. Wright Laboratory and Phillips Laboratory have reached agreements to jointly support future advanced development in the Space and Missile area. Cooperative efforts in the area of wide bandgap semiconductors are being conducted with WL/ML and WL/PO for high temperature and high power device applications.

A main interface of the Targeting and Attack Avionics Thrust with the Geophysics area, is

the development of Tactical Decision Aids and the Ballistic Winds program. Avionics efforts interface with the Advanced Weapons activities in High Power Microwaves, Lasers, and Global Positioning System (GPS) for precision guidance. The Air Force Office of Scientific Research (AFOSR) provides research support from their Life Sciences area to Avionics in neural networks and vision. Support is also provided from the Electronic and Materials Sciences areas to the semiconductor research efforts under the Electron Devices thrust.

CHANGES FROM LAST YEAR

There have been considerable changes in avionics programs as a result of budget reductions, DoD and Air Force downsizing, changes in Air Force priorities, international changes in threats, lessons learned from Desert Storm, and sharply focused investment planning as described earlier.

The Air Force is leading a tri-service effort for the development of a DoD science and technology strategy for developing avionics for new and retrofit aircraft. The strategy focuses on implementation or integration technologies required to achieve affordable improvement in avionics performance. The strategy is being coordinated with operational users to assure high priority needs are satisfied and with industry to assure realistic and achievable technology goals.

There is also an increased focus on the area of functional integration of radio frequency (RF) systems, with a goal of making avionics more affordable by integrating offensive, defensive, and Communications, Navigation, and Identification (CNI) function, databases, and off-board information sources.

In order to improve avionics systems integration research, and capabilities for faster technology development, evaluation, and transition, the Avionics Directorate is continuing its efforts to link research facilities into a "collaborative engineering environment." This modeling and simulation-based "environment" will provide a gateway to other national resources for system development and deployment, from small business researchers to the war fighter's "battle labs."

In accordance with the objectives of DoD acquisition reform and Air Force "Lightning Bolt" 11.2, the majority of contract awards during FY98 will be procured via a single broad area announcement (BAA). This procurement strategy will highlight investment opportunities within the context of the new avionics "focus areas." Highlights of planned focus area investments are provided in the following Thrust descriptions.

The technical approach for the Aging Avionics Emphasis Area is being revised in light of S&T budget reductions and limited funding available within acquisition accounts for near term technology transition. Increased emphasis is being placed on emerging aperture, receiver, and device technologies which will enable much lower cost and higher performance replacements of legacy systems.

In response to the rising interest in uninhabited reconnaissance and combat air vehicles (URAVs and UCAVs) resulting from Air Force long range planning studies, critical enabling technologies are being identified for increased investment priority. However, initial assessments indicate that a majority of current avionics technology efforts will support the needs of all platforms, including UAVs.

Ongoing reduction of S&T funding for the avionics technology program has led the Avionics Directorate to focus on development of strategic alliances with a limited set of technology development sponsors and customers having the resources to achieve technology transition and fleet improvements. These special partners include DARPA, ASC/RA, Air National Guard/AF Reserve, JSF, Navy, and Army.

The emphasis on design, modeling, and simulation will be increased to support the AF's number one design problem -- retrofitting and reengineering the electronics of legacy systems. Additional efforts will assure that simulation models most needed for Air Force systems, including those for commercial off-the-shelf (COTS) parts, will be readily available for system designer.

THRUST #1: TARGETING AND ATTACK AVIONICS

USER NEEDS

The Targeting and Attack Avionics Thrust develops technologies critical to resolving needs within the following user developed Mission Area Plans (MAPs): Force Application, Aerospace Control, Surveillance/Recce, and Special OPS Combat Support. Based upon these MAPs, the needs relative to Targeting and Attack are:

Detecting, locating, identifying, and attacking ground based mobile and fixed targets:

- Standoff capability
- Delivery of multiple weapons on a single pass
- Accurate medium/high altitude weapon release
- Quick reaction capability against short dwell surface to air missiles
- Adverse weather detection, location, and identification capability
- Improved situation awareness

Increased detection, location, and identification of airborne targets:

- Counter - countermeasures
- Off-boresight targeting
- Ability to deploy and support weapons without entering lethal threat range
- Survivability by providing first look, first shot, first kill
- Improved situational awareness
- Target identification capability
- Detection/targeting low observable threats

GOALS

The objective of the Targeting and Attack Avionics Thrust is to develop and transition, into operational combat systems, superior avionics technology to find, identify, and destroy enemy targets--anywhere, anytime, and in any weather. This includes developing affordable, obsolescent resistant, superior performing sensors through modular, multifunction, open architecture designs. Specific goals are identified below for three principal areas of technology investment: Counter Air, Air-to-Surface, and Visionary Capabilities.

Counter Air

Unambiguous situational awareness:

- Detection, identification (ID) and targeting of low observable threats
- Beyond visual range air target detection and ID
- Sustained sensor performance in jamming/ clutter environments

Enhanced weapon system effectiveness:

- Improved targeting accuracy
- Dual range missile fire control

Air-to-Surface

Precise targeting of surface threats:

- Deny adverse weather "sanctuary"
- Defeat concealment (camouflage & foliage)
- Discriminate decoys

Enhanced weapon system effectiveness:

- Precise weapon aiming
- Maneuvering targeting and weapon release for increased survivability
- Multiple kills in a single pass
- Real-time target damage assessment
- Increased stand-off ranges
- Mid to high altitude weapon employment
- Sustained sensor performance in jamming/clutter environments

Visionary Capabilities

Mission-adaptive weapon systems:

- Multifunction shared apertures
- Integrated offensive/defensive sensors
- Threat-adaptive target detection
- Model-based vision (MBV) "smart sensing"

Enhanced weapon system affordability:

- Electronically scanned sensors
- Low cost adaptive architectures
- "Reusable" software for sensor management and target recognition
- Automated scene/target rendering for mission planning and rehearsal
- All solid-state electro-optical (EO) sensors

TARGETING AND ATTACK AVIONICS THRUST

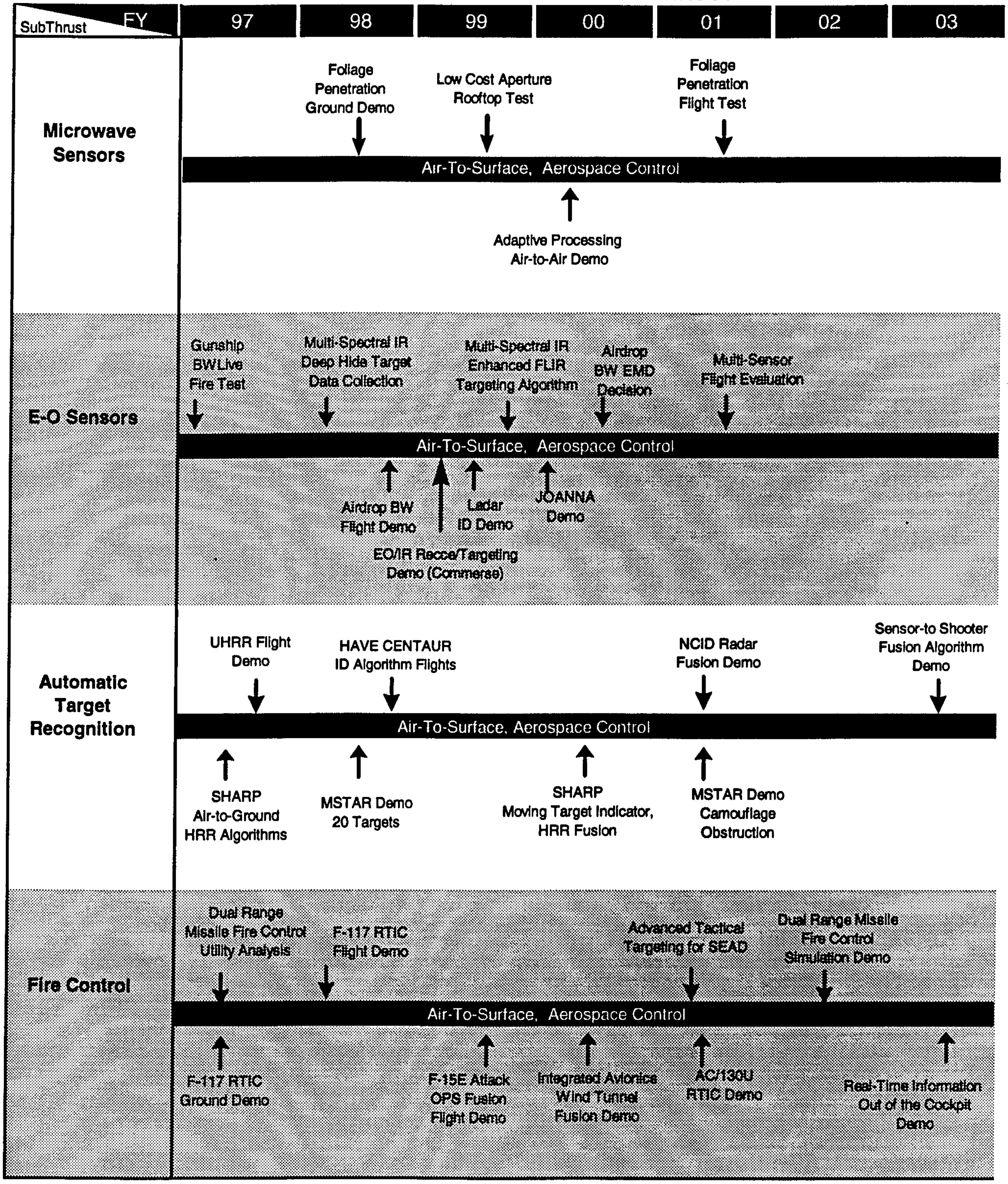


Figure 6: Target and Attack Avionics Roadmap

MAJOR ACCOMPLISHMENTS

Major accomplishments made toward meeting user needs are shown below. They are organized (as is the rest of the thrust) by the four subthrusts for investment: 1) microwave sensors, 2) electro-optical sensors, 3) auto target recognition, and 4) fire control.

Microwave Sensors:

- Counter air and air-to-surface role airborne radar clutter and barrage jamming interference data were collected using F-15 flat plate gimbaled and F-22/JSF body fixed electronically scanned type arrays mounted behind both solid fiberglass and multi-layer frequency band pass radome wall structures. Initial ground processing of this data, using innovative near-term adaptive algorithms especially formulated for low cost conventional four port monopulse array architectures, has shown that the phenomenology is well understood and that the interference can be mitigated allowing sustained sensor performance in nominal jamming and clutter environments.

- Real time image formation and automatic target detection were demonstrated using airborne collected, ultra wideband UHF data. Probability of target detection and false alarm rates look encouraging. Continued target detection algorithm and clutter suppression technique developments are expected to provide the Air Force with a significant operational foliage penetration capability. The Radar Detection of Concealed Time Critical Targets (RADCON) program, jointly conducted with DARPA, demonstrated the use of image formation and automatic target detection and cueing (ATD/C) algorithms of targets concealed by foliage in real time. The program successfully demonstrated the use of a Mercury 9U Commercial off the Shelf (COTS) chassis populated with 104 I860 processors to process real radar data containing targets concealed by foliage and collected under a previous program. The image formation was accomplished in 4.7 sec and the ATD/C in 6.1 sec. To meet the real time requirements, each stage must process several frames of data, with each frame of data not exceeding 7.4 sec.

- In support of the visionary capability, low cost radar technologies, sensor architectures, and apertures are being explored and developed. A 9" x 16" active aperture subarray was fabricated and tested, yielding encouraging results. A study was completed that identified low cost radar architectures providing the required performance and improved reliability and maintainability while reducing overall system cost. Detailed designs of these architectures are being pursued.

Electro-Optical Sensors:

- The Ballistic Winds effort successfully completed an extensive live-fire demonstration of the wind sensing capabilities of a laser radar system from an Air Force Special Operations Command (AFSOC) gunship. The results of the demonstration, in which live rounds were fired based on ballistic wind measurements, are documented in a limited-release report. A complete utility analysis on the benefits of airborne laser radar was provided to AFSOC and the Gunship System Program Office. They do not plan to move into a production phase at the moment, but may do so in the future. However, the same wind sensing technology promises improved accuracy for cargo drops, high altitude bombing, and wind shear detection by commercial aircraft. These applications will continue in FY98.

- Both the Thermal Multi-spectral sensor and the Enhanced Recognition and Sensing Ladar (ERASER) efforts demonstrated the potential for greatly improved detection and ID. Key experiments included an "existence proof" for the thermal multi-spectral sensor system using tower tests that showed greatly improved detection in all cases, and a field test for ERASER components that showed remarkable ID capability at extended ranges through fog and smoke.

Auto Target Recognition:

- Target recognition technology for long range, all aspect non-cooperative identification of air targets is being transitioned to an Air Combat Command (ACC) 6.4-funded flight demonstration. Most critical to the combat utility of this capability was the achievement of a technology breakthrough for rapid rendering of synthetic target signatures. This technology has been adopted by the intelligence community to support the target recognition efforts of other services, as well as threat definition/validation activities. A "turn-key" system to produce synthetic signatures will transition to

the intelligence community in FY98.

- Demonstration of model based ATR algorithms for Synthetic Aperture Radar sensors as a 10 target problem was successful. These algorithms shall transition in FY99 to the Semi-Automated Image Processing System that will support various reconnaissance platform groundstations.

Fire Control:

- Sensor-to-shooter demonstrations were conducted to show the benefits of real-time targeting information in the cockpit by exploiting information from off-board sensors for precision air-to-surface attack. In-flight retasking, retargetting, updating geoposition information, providing relevant target area imagery, and rendered scenes were demonstrated. These demonstrations showed a significant improvement of targeting time critical mobile targets. Two specific demonstrations were the F-15E and F-117.

- F-15E flying with Off-Board Targeting Experiments (OBTEX) image processor card set and Link 16 successfully received 9-line text, annotated imagery, and weather data digitally from Air Operations Center via JTIDS gateway on AWACS for retasking.

- F-117 – for first time – was successfully passed 9-line, imagery, route replans, and weather data via UHF SATCOM.

- The resolution of aircraft offensive radar systems was doubled, by a simple, low-cost hardware modification accompanied by an updated software program. This improved their ground strike capability and demonstrated the ability to display and track ground moving targets on a radar map.

CHANGES FROM LAST YEAR

- Integrated Fire Control/Weapon Delivery program was terminated. Improved air-to-air missile targeting and cooperative missile launch capability for enhanced weapon system employment flexibility will not be demonstrated.

- Advance broad band passive imaging sensors for targeting was terminated. The technologies from this area that are relevant to other areas, such as active target identification and situational awareness, will be transitioned to those efforts.

- The Joint Airborne Navigation and Attack (JOANNA) program was delayed one year. JOANNA will integrate key technologies from multi-spectral and ERASER and is a tri-national effort with the UK and France.

- On a positive note, the Avionics Directorate and Defense Advanced Research Projects Agency (DARPA) are working together to further Model-Based Vision (MBV) technology development and supporting infrastructure. Rapidly evolving plans represent an acknowledgment by the Joint Service automatic target recognition (ATR) community (including recce/intel customers) that the MBV discipline, pioneered within the Targeting and Attack Avionics Thrust, provides the best long-term approach to fielding critically needed ATR capabilities that are reliable and supportable.

MILESTONES

Microwave Sensors

- During the remainder of the RADCON program, algorithm performance will be enhanced to achieve operationally significant probability of detection and false alarm rates against time critical targets.

- The objective of advanced Electronic Protection (EP) technologies is increasing mission effectiveness of front-line fighters and bombers. The electronic combat (EC) threat environment is constantly evolving and providing new challenges for current radar systems. In FY98, new start efforts will develop advanced electronic protection (EP) techniques for airborne radars against advances in jammers, especially areas of potential technological surprise.

- Additional low cost, four port monopulse antenna radar interference data are to be flight collected and adaptively processed to quantify the performance achievable for the anticipated tactical scenario interference types: radome

internal reflections clutter; direct path main beam, side lobe, and terrain scattered jamming interference. Future efforts will involve flight collecting radar interference data employing far-term eight spatial degrees-of-freedom array architectures to demonstrate joint clutter and jamming interference suppression to a level approaching that of the thermal noise.

- In support of the visionary capability, low cost radar technologies, low cost ferrite phase shifters are being fabricated and will be tested in FY98. Emphasis is being given to development of synergistic adaptive processing and small active array techniques to accommodate difficult ground clutter conditions, enemy barrage noise jamming, low radar cross-section (RCS) targets, and unique radar installations within our own low observable aircraft.

- A joint DARPA/AF/Army Foliage Penetration Advanced Technology Demonstration (FOPEN ATD) is scheduled to begin in early FY98, culminating in a manned aircraft flight test of a FOPEN radar in FY00. The FOPEN radar will be an 85% form, fit, function solution to its intended Tier II+ UAV application.

Electro-Optical Sensors

EO sensor technologies offer the unchallenged advantages of stealth and precision for pilotage, target identification, weapon aiming, obstacle detection, and short range environmental sensing. While there is performance degradation in severe weather, EO has an additional advantage related to human factors--rate of sensing and relative ease of image interpretation. During FY98, EO investments will:

- Exploit these advantages for covert pilotage with simultaneous target search, target/decoy discrimination, identification, and wind-corrected delivery of weapons and cargo.

- Perform data collection to support development of computer algorithms for wind-corrected cargo release. These algorithms will be used in the Precision Air Delivery demonstration (ATD) in FY98 being conducted jointly with the Flight Dynamics Directorate.

- State-of-the-art solid state laser radar wind profiler, nicknamed the Windmaster III, will be completed.

- The Joint Multi-Spectral Sensor Program (JMSP) will develop the technology required to perform passive, wide area search, detection, bomb damage assessment, and automatic target cueing, while overcoming the effects of camouflage, concealment and deception. In FY98, JMSP will collect multi-spectral data from a tower and evaluate targeting algorithm performance in preparation for flying the multi-spectral sensor on a WB-57 aircraft in FY98. The program emphasis is to provide targeting system performance trade data in support of the Reconnaissance SPO budgeted transition for a modular real time targeting capability for multiple reconnaissance vehicles.

- The ERASER program will conduct a long range field test demonstration of non-cooperative ground target ID at 20km ranges prior to optimization and packaging the system for flight evaluation. The packaging will be done in an available flir sensor and will provide non-cooperative ID at the same range that the flir detects the target. The packaging demonstration in flirs will lower the risk of this low cost system upgrade.

- In FY97-98 architecture studies will be conducted in support of the long term vision of multifunction, integrated EO systems. Such studies will investigate the ability to and utility of merging the multiple required functions. These studies will be supported with laboratory and field experiments to build the technology foundation for integrated, multifunction sensors. In addition, several SBIR efforts are developing multifunction compatible components in the technical areas of laser radar sources, receivers, and optical apertures. Research initiatives sponsored by the Air Force Office of Scientific Research also support the Technology Base. Follow-on programs will develop and demonstrate multifunction systems with the goal to provide the concepts and components for affordable, reliable, and high performance EO sensor suites.

- A new start for FY98, Complementary Multi-platform EO/IR Reconnaissance & Targeting System Enhancements (COMMERSE) will develop and demonstrate a multi-spectral sensor system optimized for fusion with existing airborne radar systems in support of the Reconnaissance SPO FY00 new start to develop an integrated real time targeting capability.

Auto Target Recognition

The rapidly evolving discipline of MBV invokes the tools and processes of target, background,

and environment modeling, smart sensing, and hypothesis testing. Frequently misunderstood to be an ATR "algorithm" alternative, MBV provides a scientific framework for synthesis, application, evaluation, and mission support for all ATR algorithms. This approach, pioneered by the Wright Laboratory Mission Avionics Division, is now widely accepted and being pursued cooperatively, many of which are formal agreements, with members of other services, industry, other Government laboratories, universities, DARPA, and the intelligence community.

- Performance validation of the algorithms for all-aspect angle, long range non-cooperative ID of air targets is on-going and will transition to operational testing under ACC 6.4 funding when appropriate. Synthetic target signature generation capability began in FY95 and will continue through FY00.

- Using the same MBV principles and target signature prediction tools cited above for air target identification, synthetic signatures of surface targets are predicted for high resolution SAR imagery. Already usable, to a limited extent, by the intelligence community for threat definition/validation, the same signatures provide reference models for maturing ATRs. Groundbased experiments will be conducted during FY98 to quantify performance of existing algorithms to support automated target cueing within U-2R, Moving and Stationary Target Acquisition and Recognition (MSTAR), and Theater Missile Defense (TMD) applications for Joint Surveillance Target Attack Radar System (JSTARS).

This technology will also provide the ACC TMD and combat ID programs with the ability to locate, identify, and attack massed armor, theater missile launchers and supporting infrastructure. In FY98, this effort will complete demonstration of an integrated radar and Forward Looking IR (FLIR) equipped with an automatic target cuer/recognizer for precision target detection and cueing.

- New efforts have been initiated jointly with DARPA and National Imagery and Mapping Agency (NIMA) to develop interactive ATR and image exploitation for SAR, SIGINT, FOPEN radar, and information fusion in the DoD intelligence/surveillance/reconnaissance platforms. These efforts are addressing the need to find camouflaged and concealed targets in various configurations.

- A new joint effort was initiated with DARPA for adding radar moving target classification capability to the U-2R, with growth application to the Global Hawk and Darkstar UAVs. This effort employs UHRR ATR algorithms, applied to ground moving targets. Demo of this capability is planned for FY98-99 timeframe.

- Future investments will explore the use of MBV principles as a framework for automation of "situation determination." Preliminary assessments of this vision indicate MBV methods of evidence accrual and hypothesis formulation are directly usable for sensor and information fusion to reduce crew-member and image analysts workload and decision timelines.

Fire Control

- Based on recommendations from the Scientific Advisory Board, advanced Armed Unmanned Air Vehicle targeting concepts will be developed.

- Continuation/expansion of the F-117 RTIC technology. In conjunction with the F-117 SPO, perform ground testing of a Common Low-Observable Auto-Router (CLOAR) algorithm in a commercial off-the-shelf processor.

- Complete fire control concept development to support the WL/MN Dual-Range Missile.

- Complete advanced cooperative attack air-to-surface fire control concept study.

- Initiate joint DARPA program for Advanced Tactical Targeting Technology to develop and demonstrate technologies for affordable, accurate, rapid threat geolocation for lethal targeting of Suppression of Enemy Air Defenses (SEAD).

THRUST #2: ELECTRONIC WARFARE TECHNOLOGY

USER NEEDS

The Electronic Warfare (EW) Thrust develops technologies critical to resolving penetration and survival deficiencies within the following user-developed Mission Areas/Plans (MAPS): EW, Counter Air, Close Air Support, Strategic Attack/Interdiction, Missile Warning, Air Mobility, Surveillance/Reconnaissance, Intelligence, Theater Missile Defense, Combat Delivery, Rescue, Air Base Operations, Flying Training, and all Special Operations Mission Areas.

Deficiencies in the area of Electronic Warfare are classified; however, general user needs fall into the following categories:

- Accurate threat warning and combat identification (ID) in all portions of the frequency spectrum to aid situation awareness and reduce fratricide
- Affordable, timely, and precise ground emitter location through a wide frequency spectrum
- Defeat of infrared (IR), laser, and imaging guided missiles by on-board/off-board countermeasure (CM) concepts
- Affordable warning of missile threats regardless of guidance method (IR, semi-active radar or active radar seekers) and at maximum possible range to cue the optimum CMs and alert aircrews
- Defeat infrared target trackers that give SAMs, MANPADs, and AAA a day/night capability
- Denial of effectiveness of radar controlled threat weapons through use of on-board/off-board CMs
- Improvement of support CMs through EW payload improvements of both manned and unmanned air vehicles (UAV)
- Electronic attack (EA) of advanced modern digital, autonomous and netted ground/airborne command and control systems
- Denial of the use of advanced navigation aids by threat systems

Goals

The mission of this thrust is to develop and transition into operational combat systems, effective and affordable EW technology that will assure aircraft penetration, survivability and mission accomplishment. This requires technologies providing aircrew threat alert and effective CMs against current and evolving threat weapon systems in a wide variety of mission scenarios. When applicable, new avionics models and simulations using DoD standards will be developed. As an information player, this thrust promotes a philosophy of open-architecture integrated avionics. Six major areas of technology investment and their goals are summarized below.

Radar/Missile ECM

- Develop effective, robust, radar CMs to degrade threat acquisition and deny missile launch
- Develop advanced techniques to counter RF missiles in the "end game"
- Evaluate electronic countermeasures (ECM) against exploited foreign threats
- Develop advanced technology to assure affordable and reliable solutions

Missile/Laser Warning

- Develop low cost IR missile warning capability
- Increase detection range of low and suppressed IR signature threats in dense IR clutter
- Develop approach for combined functions of missile warning, navigation and defensive IR Search and Track (IRST)
- Demonstrate combined functions in a flight demonstration with distributed apertures and real-time processing
- Develop laser warning capability for aircrew warning and protection

Situation Awareness/Threat Alert

- Improve aircraft field of view coverage for high priority signal/threat detection, precision location and combat identification
- Develop data fusion of on-board and off-board information to enhance situational awareness
- Provide Real-Time Information in the Cockpit (RTIC)
- Exploit advanced processing technology to assure affordability of situational awareness capabilities

Infrared Countermeasures

- Develop deceptive jamming IR countermeasures (IRCM) to assure future survivability against advanced IR and imaging guided missiles
- Develop CM techniques for electro-optical (EO) and laser threats
- Conduct seeker exploitation to assure technique effectiveness against counter-countermeasure (CCM) circuits

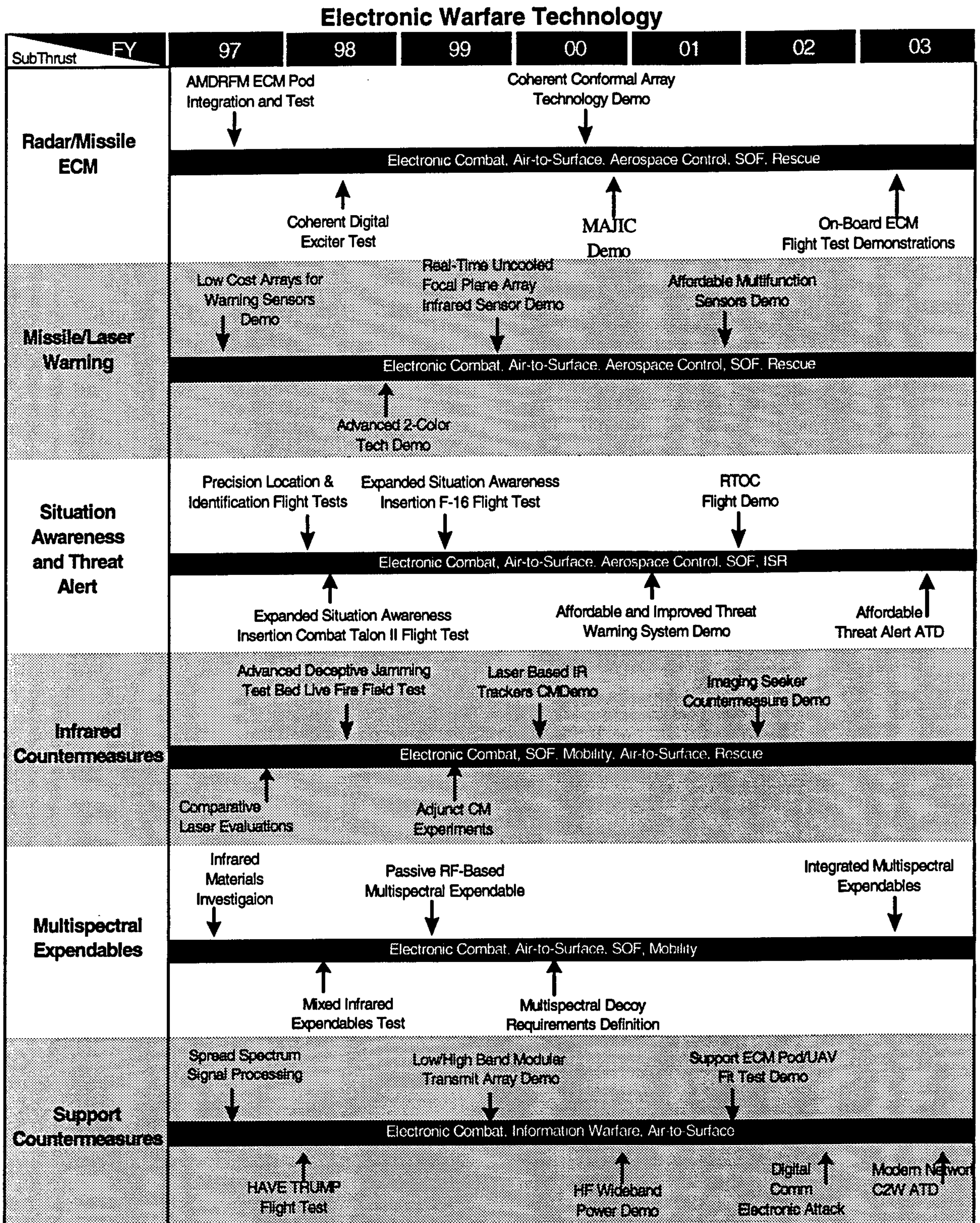


Figure 7. Electronic Warfare Technology Roadmap

Multispectral Expendables

- Develop active and passive RF decoy techniques/technologies which effectively defeat the missile threat
- Develop IR decoy technology
- Develop dual mode/multi-mode (e.g., IR/RF; micro-/millimeter wave) decoys to effectively degrade mis-

sile seekers using either or both portions of the spectrum

Support Countermeasures

- Detect, exploit and counter modern digital command and control information distribution systems
- Develop EA of threat airborne navigation and identification signals
- Base EA developments on commercially available technology
- Develop means to stimulate threat radar network via electronic payloads on UAVs
- Develop jamming technology to degrade early warning, acquisition, and ground control intercept radars suitable to UAV or podded applications.

This thrust's ultimate vision is to continually provide timely, prioritized, and effective solutions to meet User's EW operational needs. This requires continuing baseline research into new concepts against evolving threats to assure the enemy cannot benefit through "surprise" threat technology. Baseline technologies will be translated into solutions for real needs through a timely, highly focused program of work.

Major Accomplishments

Radar/Missile ECM: The Advanced Monolithic Digital RF Memory (AMDRFM) was enhanced to include multiple Digital RF Memories (DRFMs) on a single chip and run at a clock speed up to 100 MHz. Multiple DRFMs on a single chip provide capability for handling multiple threats. AMDRFM enhancements continue with the ultimate goal of providing an affordable coherent jamming capability for all current and future ECM system.

The Defensive Airborne Missile (ECM) System (DAMES) Program: Performed the initial air-to-air missile live-fire test of an affordable self-protection end game countermeasures. This test allowed collection of highly instrumented missile three-dimension behavior data in the presence of end-game countermeasures.

Missile/Laser Warning: Improved clutter rejection algorithms were demonstrated for staring IR warning systems that will provide a 2X improved detection range in highly cluttered backgrounds. The feasibility of using uncooled IR focal plane arrays was demonstrated in the laboratory. The sensor and processor are to be flight tested in an internationally coordinated effort.

Laser effects phenomenology and modeling efforts were conducted against an F-16 with Air Combat Command (ACC) aircrews on the Wright Laboratory Aircraft Turntable Facility. This work is in support of the Precision Guided Munitions (PGM) program involving Wright Laboratory (Avionics and Materials Directorates), Armstrong Laboratory , and the Air Staff. The results will guide eye protection and CM technology development used to provide warning and cueing against lasers on the battlefield, such as laser rangefinders and the laser beamrider missile.

Situation Awareness/Threat Alert: A preliminary flight test of a brassboard, single channel version of the Precision Location and Identification (PLAID) hardware and software provided an initial look at the performance of the PLAID system. This test validated PLAID hardware performance to the minimum resolution required for the location and ID software. Both time and frequency based Doppler ranging were successfully performed in flight, while the specific emitter ID algorithms were validated in post-flight analysis.

The Expanded Situation Awareness Insertion (ESAI) Program's Real Time Symmetric Multi-Processor (RTSMP). The ABCCC Program Office gave an award for a build of fourteen RTSMP hardware and software based Intelligence Broadcast Data Upgrades to the eight operational ABCCCs to provide situational awareness and threat warning from UHF satellite broadcast.

Infrared Countermeasures: An offboard laser CM system was demonstrated from an airborne platform in testing at White Sands Missile Range (WSMR). Working in conjunction with the Office of the Test Director (OTD), the tests showed that the trailing fiber optic cable system consistently protected the platform from laser guided weapons. Upon detection of the threat, the system would initiate a deceptive jamming routine that countered two different threats representative of a broad range of threats.

An expendable laser jammer was also demonstrated for protecting aircraft against laser threats. Tests at WSMR in conjunction with OTD showed that an expendable device could protect an aircraft from a laser guided weapon.

The Laser Infrared Flyout Experiments (LIFE) program conducted a successful System Requirements Review (SRR) in early FY97. The

program identified the key technology drivers for the laser source, pointing and tracking system, missile approach warning and other key subsystems. The end result was a system specification for airlifter type aircraft.

Two new start programs were initiated in the area of imaging IR seeker countermeasures. These programs are aimed at investigating the imaging seeker threat and the effects of platform signature on the performance of imaging sensors. Each of these programs is attempting to address the imaging threat from a "generic" standpoint. Information from these programs will feed the imaging seeker CM demonstration scheduled for FY01.

Two new start programs were initiated in the area of beamrider countermeasures. There are two concepts being explored, fused jamming and kinetic kill. The programs will go through a downselect and the chosen concept will be demonstrated in late FY98.

Multispectral Expendables: In an effort to develop a "family" of IR decoy flares for aircraft, several flare designs were tested in a high speed windstream. Several of these designs demonstrated spectral properties which closely matched the IR signatures of a high speed aircraft in comparison to standard decoy flares. This type of technology is significant in that it can be very effective against certain threats, where CM effectivity is very difficult to achieve at speeds greater than Mach 0.5.

Research in the area of special materials for IR decoy flares resulted in the testing of materials with very quick reaction capability. The reaction rate of these materials is significantly greater than the more conventional forms of special materials. By combining the fast reacting materials with the more conventional materials, improved performance against advanced IR missiles may be realized.

Multiple efforts to develop advanced RF power modules for towed RF decoys proceeded through the design, fabrication and testing phases. These include both microwave power module (MPM)-based and solid state amplifier developments. These programs are anticipated to have a profound impact upon AF implementation of the Integrated Defensive ECM (IDECM) Program.

Support Countermeasures: Multiple demonstrations were concluded this past year, including those of effective CM techniques from an airborne platform against specific ground and airborne target navigation signals; and EA demonstration against specific analog and commercially available digital communication signals.

Under the Defense Reliance Technology Panel for EW (TPEW), a tri-service Support CM roadmap was developed. The draft plan ties together key laboratory technologies in support of a future ATD/ACTD flight test demonstration of a next generation UAV/podded support jamming capability.

Changes From Last Year

The major change from last year is the "elevation" of the Large Aircraft IRCM Program to full ATD status. AF EW S&T funding strategies were adopted to support this position, while still emphasizing strong commitments in the Support Countermeasures, and Situation Awareness/Threat Alert technology investment areas. This strategy continues to be guided by extensive User community inputs and includes cooperative programs with other AF laboratories, Army and Navy organizations.

Under the Laser Infrared Flyout Experiments (LIFE) effort, the program was modified to perform the technology risk reduction required for transition to Engineering Manufacturing Development (EMD) at the end of the program. The modification was required to support the deceptive infrared (IR) jamming requirements in the AFMC/ST's Large Aircraft Infrared Countermeasures (IRCM) ATD. The LIFE program was not originally intended to support an ATD, and technology improvements were needed in the areas of laser sources, pointing and tracking, and missile approach warning to demonstrate the sensitivity, packaging, and accuracies requirements for an EMD system. There is an additional requirement by OSD that the testbed be demonstrated in a captive carry environment from a large aircraft, however there is no funding available for a captive carry test at the present time. Discussions are ongoing with OSD and the user (AMC) in an effort to identify funds for captive carry testing.

Milestones

Radar/Missile ECM

The first row of the roadmap describes milestones related to Radar/Missile ECM. Technologies embodied in this EW area are central to the DoD/OSD national Defense Technology Objectives in the Defense Technology Area Plan (DTAP) and the Joint Warfighter S&T Plan (JWSTP) – WE.46 (Coherent RFCM), and H.08 (Onboard ECM Upgrades), respectively.

- 3Q97 - Integrate the AMDRFM in an operational jamming system and conduct tests in a simulated threat environment.
- 3Q98 - Evaluate the coherent digital exciter (CoDE). This is the fundamental building block for all future jammers to generate jamming signals against coherent monopulse radars.
- 3Q00 - Demonstrate the coherent conformal array technology to provide advanced ECM antennas that maintain low observability.
- 4Q00 - Proof of concept testing/evaluation of robust monopulse angle jamming technique (MAJIC)
- 4Q02/1Q03 - Demonstrate the effectiveness and affordability of ECM upgrades for operational pods using advanced ECM techniques generated with DRFMs, dual polarized array antennas, microwave power modules (MPMs) and monolithic microwave integrated circuits (MMIC) technology.

Missile/Laser Warning

The second row on the roadmap lists four major milestones. Three of these milestones lead to an out year milestone to demonstrate **a significantly lower cost** missile warning system. The issues of time-critical, high accuracy, and low false alarm warning are absolutely critical to solve, and the efforts herein play an integral part of the Tri-Service DTAP Defense Technology Objective (DTO) WE.48 on Missile Warning Sensor Technology.

- 4Q97 - Demonstrate processor algorithms with uncooled IR detector arrays to recover signal to noise for the reduced sensitivity of uncooled IR detector arrays. Current focal plane arrays require cryogenic coolers that provide increased performance but have multiple drawbacks. The payoff is very low cost IR focal plane arrays to allow low cost IR missile warning systems.
- 2Q98 - Identify requirements for aircrew warning and protection from laser threats.
- 4Q98 - Demonstrate advanced two-color warning sensor technology.
- 3Q99 - Flight test of uncooled IR sensor with real time algorithms.
- 3Q01 - Demonstrate multiple function IR sensor with real time processing in a flight demonstration to include missile warning, navigation and defensive IRST capability in each aperture of the sensor suite. Program will use affordable arrays and a commercial processor

Situation Awareness and Threat Alert

The third row of the roadmap provides seven milestones delineated below for this highly rated MAJCOM subthrust. The technologies form the very foundation to achieve the goals expressed by the JWSTP DTOs, namely H.07 (ESAI) and H.09 (Sensor Fusion/Integrated Situation Assessment).

- 1Q98 - Combat Talon II flights demonstrating off-board/on-board all source data fusion for infiltration/exfiltration profiles emphasizing intent prediction, pop-up threat response, threat precision location and specific emitter identification.
- 1Q98 - Flight test Precision Location And IDentification (PLAID) hardware/software to demonstrate significantly improved precision threat radar location and specific emitter identification functions.
- 1Q99 - F-16 flights demonstrating all source data fusion for Reactive/Preemptive/Hunter Killer Suppression of Enemy Air Defense (SEAD), and Battlefield Area/Deep Interdiction missions.
- 1Q99 - PLAID AF Reserve Demo and validation flight test will quantify the system in an operational RF environment and provide risk reduction for PLAID AF Reserve EMD effort.
- 3Q01 - Demonstrate an **affordable, significantly improved** threat warning system against advanced emitters. Substantial cost savings result from the maximum use of MMIC, digital receiver technology and commercial processors.
- 4Q01 - Initial Real-Time information Out of the Cockpit (RTOC) flights demonstrating multi-platform situational awareness, targeting/retargeting, ownship status and battle damage assessment.

- 4Q03 - Integration of ESAI, PLAID, and digital receiver/beamforming technologies into affordable alert architecture

Infrared Countermeasures

The fourth row of the roadmap provides milestones for the development of laser-based CMs against IR threats and laser beamrider missiles. For several consecutive years, OSD/DDR&E has identified this arena as the number one EW priority across the three Services, and the AF program herein is absolutely central to the cooperative Tri-Service investment strategy. The Avionics Directorate IRCM program plays a pivotal role in the DTAP (DTO WE.47 on Imaging IR Seeker CM) and the JWSTP (H.05, the Large Aircraft IRCM Program).

- 3Q97 - Complete evaluation of four different types of lasers against a variety of advanced IR missiles. Brief the results to the SAB.
- 1Q98 - Identification of final design parameters for an IR deceptive jamming system for large aircraft.
- 3Q98 - Validate the concept of using closed-loop/open-loop techniques as a robust CM for large aircraft via the advanced IRCM test-bed and evaluated during a live fire field test at White Sands Missile Range.
- 4Q00 - Demonstrate laser-based CM concepts for IR trackers that give SAMs, MANPADs, and AAA day/night target tracking capability.
- 4Q01 - Demonstrate CM techniques against imaging seeker to include jamming, expendables, and cooperative techniques.

Multispectral Expendables

The milestones for this area of the roadmap place primary emphasis on reducing the risk of developing a multispectral (RF/IR) expendable decoy. This leads to an out year 2003 program providing a single expendable to counter seekers using RF, IR or combinations of both. This dual CM approach will provide an increased missile CM capability as well as significant savings in CM acquisition and logistic costs.

- 2Q97 - Investigate and test next-generation expendables advanced flare compositions.
- 1Q98 - Integrate and field test promising new advances in IR flare techniques and technologies through the Mixed IR Expendables effort.
- 3Q98 - Laboratory demonstration of an advanced, passive RF-based, multispectral expendable concept.
- 1Q99 - Demonstrate advanced IR decoy technology in a flight test against ground based captive IR missile seekers.
- 4Q99 - Integrate results of above efforts, as well as current and projected applicable threat intelligence, into modeling and simulation tools to determine multispectral decoy requirements definition. The results of these concentrations will then culminate in an FY03 risk reduction to integrate both the RFCM and IRCM techniques and technologies into a single expendable that will function within existing CM dispenser systems.

Support Countermeasures

The milestones for this area of the roadmap include developments leading to an outyear program which will demonstrate a capability to find the correct information network worldwide and surgically apply the proper CM techniques. This would deny a specific hostile force access to information that would otherwise help target lethal weapons against our forces. In past Technology Area Review and Assessment (TARA) panel evaluations at the OSD/DDR&E level, Command and Control Warfare (C2W) has been identified as a top priority in EW S&T investment, and the related programs embodied herein play in integral role with the Army in DTAP DTO WE.23.

- 3Q97 - Develop theory and algorithms for the detection, characterization, and exploitation of spread spectrum waveforms.
- 4Q97 - Develop and flight test a capability to counter specific communication links without affecting other contiguous links. (HAVE TRUMP)
- 4Q99 - Develop and demonstrate miniaturized modular high power array transmitter technology with wideband capability.
- FY00 - Demonstrate a ten-fold increase in wideband power generation with a comparable package
- FY01 - Flight test a full system brassboard of a support ECM pod to demonstrate ground integrated air defense network degradation.
- FY02 - Demonstrate ES/EA capability against LPI/LPD communication links characterized by featureless, time-division, and code division multiplexing formats.
- FY03 - Initiate Modern Network C2W ATD effort in Defense Reliance cooperation with Army/Navy

THRUST #3: SYSTEM AVIONICS

USER NEEDS

Many user needs have been identified through Air Force Materiel Command's (AFMC's) Technology Master Process, and the joint AFMC/Air Combat Command (ACC) Fighter Configuration Plan. These technology needs flow directly down from the operational deficiencies described by the Major Command (MAJCOM) users. The Scientific Advisory Board Summer Study on Aging Aircraft identified Avionics as one of only two high leverage opportunities for extended life of our operational aircraft and AFMC/ST has identified aging aircraft as a thrust area and Aging Avionics as a potential emphasis area. The System Avionics Thrust develops technologies critical to resolving deficiencies in the following mission areas: Air-to-Surface, Counter Air, Special Operations Mobility of Forces in Denied Territory, Surveillance/Recce/Intel, Electronic Combat, Information Warfare, Mobility, Force Enhancement, Strategic Deterrence, & Modeling/Simulation. Further, these deficiencies have been prioritized across the fighter fleet. Deficiencies relative to System Avionics include:

Inadequate Situational Awareness

- Off-board sources
- On-board sources
- Information processing and fusion

Avionics for covert operations

- Covert penetration
- Passive navigation
- Covert communications

Susceptibility to jamming

- Global Positioning System (GPS)
- Tactical communications

Dissemination of time critical data

- Targeting
- Threat
- Recce/Intel
- Bomb Damage Assessment (BDA)
- Missile Warning

Affordable, flexible, reliable, sustainable, available avionics

- Line Replaceable Unit/Module commonality
- Automated Software design/support
- Disposable Avionics
- Open/hybrid architecture
- Tool for obsolescence management
- Mission/UAV Adaptability

Avionics for aging aircraft

- Integrated modular avionics across fleet
- Integration technology for legacy systems

GOALS

The objective of the System Avionics Thrust is to develop and transition into operational combat systems superior integrated avionics for full-spectrum offensive, defensive, and Communication, Navigation and Identification (CNI) operations. The technologies pursued in this thrust find pervasive application across the full range of combat missions and operational aircraft. The specific goals, as related to the deficiencies, reflect benefits to be achieved for the most stringent/demanding of requirements. Significant avionics cost, size, and weight savings have been shown for fully-fitted multiple-role aircraft. Benefits to other platforms, aging systems and related mission areas are scaleable.

Inadequate Situational Awareness

- Incorporation of off-board sources
- No mission impacts due to Operational Flight Program (OFP) anomalies
- Flexible/low-cost/open architecture signal & data processing
- Improved avionics with machine intelligence
- Automated UAV control/information integration
- Missionized Sensor Suite Architectures
- Improve displays for form, fit, function retrofit (F^3R) to existing aircraft and use in advanced aircraft. These displays will be fully sunlight readable (>200fL) and have a 30-100 fold mean-time-between-failure (MTBF) improvement over today's electromechanical (EM) and cathode ray tube (CRT) displays.
- \- large area (200-300 sq. in.), high definition (>1280x1024 color pixels), high situational awareness (SA) Active Matrix Liquid Crystal Display (AMLCD)
- \- Digital Micromirror Device (DMD)
- \- Organic Light Emitting Diode (OLED)
- \- Field Emissive Device (FED)
- \- Flat panel cockpit and mission displays

SYSTEM AVIONICS THRUST

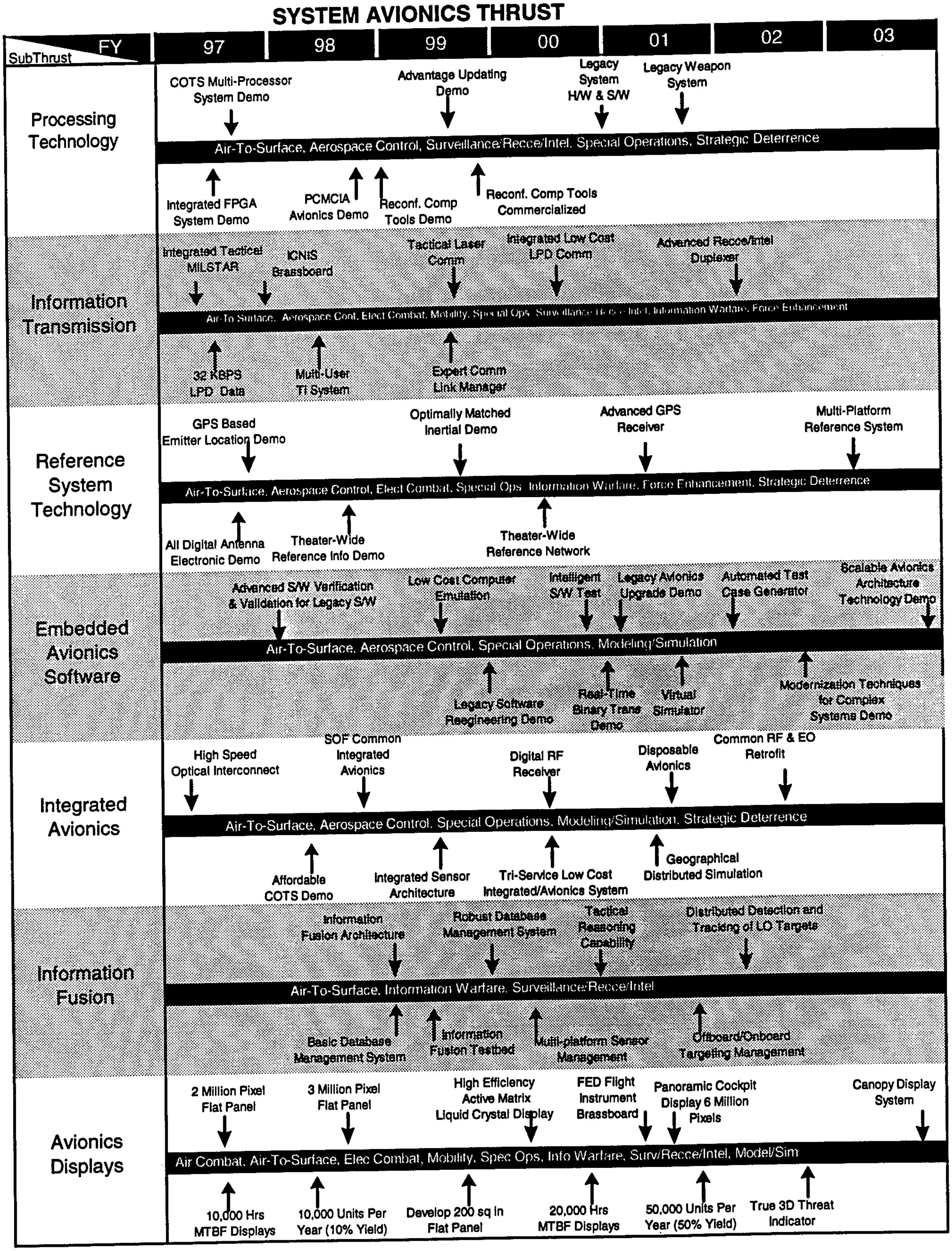


Figure 8. System Avionics Roadmap

Avionics for stealth operations

- Electromagnetic signature - reduce sphere of vulnerability 80 percent
- Passive reference system accuracy - three-fold increase
- High rate data transfer for covert cooperative engagements
- Low cost, low probability of detection voice & data transfer

Susceptibility to avionics jamming

- Jamming susceptibility of communication & reference systems - Reduce 50%
- Fault tolerant, integrated, nonemitting reference
- Jam-resistant, high accuracy GPS receivers

Dissemination of time critical data

- Target, threat, recce, BDA information dissemination - reduce timelines from days & hours to minutes & seconds
- Shareable database for system-wide exploitation

Affordable, flexible, reliable, sustainable, available avionics

- Emergency changes to OFP under 24 hours
- OFP test stations - Reduce cost 50%
- OFP test - 100 times faster and 1/10 labor
- OFP development and maintenance - 10 times productivity
- Improve avionics flexibility & availability with reinforcement learning
- OFP block cycle changes In budget under 1 year
- Avionics weight - reduce 50%
- Avionics volume - reduce 50%
- Reliability - improve three-fold
- Flight-line maintenance personnel - reduce 20%
- Guaranteed-predictable processing
- COTS technology and standards to reduce avionics cost
- Design tools for obsolescence management

MAJOR ACCOMPLISHMENTS

In order to meet the user needs, this thrust is organized into six subthrusts: 1) Processing Technology, 2) Information Transmission, 3) Reference System Technology, 4) Embedded Avionics Software, 5) Integrated Avionics, and 6) Information Fusion

Processing Technology

- Developed a 325,000 gate reconfigurable computer using commercial-off-the-shelf (COTS) field programmable gate array technology. Developed advancements in the programming technology for these computers. Reconfigurable computers can have their internal logic customized by the programmer to match the application. This yields supercomputer class performance at a fraction of the cost and a lower size, weight, power, and life-cycle cost than conventional computers.

- Completed the first phase of the COTS-based Real-time Avionics Parallel Computer project. This phase used simulations to investigate the feasibility of using the Scalable Coherent Interface (SCI) for multiprocessing in an embedded avionics environment. SCI is the IEEE standard for interconnection. This phase confirmed the potential for applying SCI to some real-time avionics processing requirements and provided the basis for continuing into the second phase.

Information Transmission

- Demonstrated advanced cosite interference reduction technologies for frequency hopping radios.

- Completed testing of Integrated Tactical Milstar system.

- Demonstrated ultra-wideband cover communication capability.

- Demonstrated innovative methods to convert F-22 integrated CNI liquid cooled modules to air cooling.

Reference System Technology

- Conducted flight trials of an advanced airframe flexure compensation technique which combines both high and low bandwidth compensation to improve sensor motion correction and weapon delivery.

- Completed characterization testing of the first iteration Precision Fiber Optic Gyroscope for next-generation high accuracy inertial navigation systems.

- Completed analyses of Navigation Warfare Anti-jam GPS technology using Wright Laboratory's (WL's) Wavefront Simulator, which simulates a multi-element antenna array in a dynamic threat environment. The results are being used by the GPS Joint Program Office,

F-117A System Program Office, the 746th Test Group, and WL/MN.

Embedded Avionics Software

- Demonstrated new test capability for electronic warfare systems including fully automated test execution and automated side-by-side comparison testing. Demonstrated on an ALR-69 Hot Bench at Warner-Robins Air Logistics Center. Seventeen copies are now in use or on order.

- Demonstrated a Reconfigurable Avionics Computer Emulator (RACE) executing an F-16C/D Block 40 General Avionics Computer (GAC) Operational Flight Program (OFP). The RACE executed actual flight software in real time and was tested against a real GAC in a ground-based F-16 simulator.

- Demonstrated software design complexity metrics. Showed a direct relationship between design metrics and key project cost drivers.

- Demonstrated the feasibility of automatically generating weapons-system software tests from a functional representation of the avionics system.

Integrated Avionics

- Completed Critical Design of the Integrated Sensor System focused on 50% reduction of size, weight, and power and a three-fold improvement in reliability for radio frequency (RF) support electronics.

- Determined Near-Term Application of COTS products to B-2, F-16, F-15

- Conducted Aging Avionics Workshop with AFMC/ST, SPOs, and Weapon System Contractor to develop Science and Technology Investment Strategy for Aging Systems.

- Completed third National Distributed Interactive Simulation (DIS) demonstration with required DIS modes, simulation interface software implemented in Ada, and actual avionics hardware-in-the-loop.

- Completed Special Operation Forces baseline demonstration of low altitude penetration algorithms in the Integrated Test Bed (ITB).

Information Fusion

- Demonstrated integrated on-board, real-time avionics database management system components.

- Demonstrated baseline information architecture for avionics data fusion.

- Demonstrated basic, real-time, object-oriented avionics database management system for common data store/sharing types.

Avionics Displays

- Established panoramic/immersive digital display laboratory

- Demonstrated fixed format and segmented symbol green OLED display

- Established feasibility of using metal and plastic substrates (as low as 125 C)

- Demonstrated 20 lm/W efficiency in emissions from a thin-film edge emitter array on low voltage phosphors

- Demonstrated quantum well technology for compact, high luminance solid state displays

CHANGES FROM LAST YEAR

Wright Laboratory initiated integrated modular avionics programs for both near and far-term update of aging avionics. A refocused project in the Advanced Avionics Integration Program Element (PE 63253F), called Integrated Avionics for Aging Aircraft, was formulated to develop and transition common integrated avionics technology across the existing aircraft fleet. Added emphasis by AFMC/ST has resulted in the defining of this program element as the basis for an Aging Avionics Emphasis Area.

The Dynamic Avionics Real-Time Scheduling (DARTS) program was terminated due to budget cuts.

Funding for Binary Translator for Avionics Systems was significantly reduced due to budget cuts. Technical effort was redirected to leverage existing in-house resources.

The affordable COTS for Aging Aircraft was initiated with considerable interest from industry.

As a result of Secretary Perry's and Dr. Kaminski's memos on "best commercial practices" and "open systems", industry, through this program, is addressing the use of COTS for currently fielded systems.

The Legacy Software Reengineering Technology (LSRET) FY96 new start was awarded. This program will focus on reengineering legacy Jovial operational flight programs to well structured, well documented, logically and algorithmically identical, Ada source code.

Computer Aided Engineering For Reconfigurable Computing (CAERC), an FY97 new start, was awarded. CAERC will make the emerging reconfigurable computer genre, with their small size, low cost, and supercomputer computational capability, more programmable. This will make them more effective for Air Force applications and greatly reduce the level of difficulty and expertise required to use them. As reconfigurable computing technology becomes mature, it is expected to be used pervasively in AF systems.

The Avionics Directorate initiated an effort to develop a Collaborative Engineering Environment (CEE) which will enable technology information sharing through the use of engineering design tools , software development, and modeling and simulation assets. The CEE will enhance new technology research and development, system concept exploration, and technology experimentation and test. The CEE employs virtual prototyping to enable multiple domain technology sharing and integration for knowledgeable decision making and effective engineering, design, and cost tradeoffs.

MILESTONES

Major milestones in the System Avionics Thrust include the following:

Processing Technology

- FY97 - Complete feasibility study for applying commercial Personal Computer Memory Card International Association (PCMCIA) technology to avionics. Build prototype PCMCIA avionics system and evaluate using COTS components.
- FY98 - Complete prototype militarized PCMCIA system evaluation and determine retrofit strategies for existing aircraft.
- FY98 - Demonstrate a university-grade ingrated programming (a.k.a. synthesis) environment for complete automated user customization of reconfigurable computers.
- FY99 - Release a commercial-grade spin-off of the reconfigurable computer programming tools for Beta test by organizations pioneering the application of reconfigurable computers.
- FY01 - Transition legacy computer upgrade methods to weapon system contracters for aging aircraft.

- **Information Transmission**

- FY98- Demonstrate 1.54 Mbps airborne local area network for secondary dissemination of time critical information.
- FY98 - Demonstrate solar blind ultra violet communications breadboard for non-line of-sight covert data transfer for aerial refueling and nap-of-the-earth operations.
- FY99 - Demonstrate voice activated expert communications link manager.
- FY00- Demonstrate low cost real-time adaptive techniques to improve Low Probability of Detection/Jam Resistant (LPD/JR) performance and electromagnetic interference/compatibility.
- FY02 Demonstrate advanced duplexing/filtering technology to reduce radio frequency signal losses for multiple wideband frequencies.

Reference System Technology

- FY97 - Conduct evaluation of the second iteration Precision Fiber Optic Gyroscope for high-accuracy passive navigation.
- FY97 - Demonstrate first iteration of navigation-grade, micro-machined vibrating beam accelerometer to lower cost and improve reliability of aerospace inertial reference systems.
- FY98 - Flight demonstrate low-cost, threat emitter locator for tactical aircraft using GPS, radar warning receivers (RWR)s, and short range, air-to-air data link.
- FY98 – Conduct laboratory demonstration and quantify the benefits of a theater-wide common reference system to enable sharing of imagery, threat, targeting, and feature information.

Embedded Avionics Software

- FY97 - Demonstrate performance measurement capability for avionics software systems.
- FY98 - Develop technology for simultaneous execution of legacy software with newly upgraded avionics software.
- FY99 - Demonstrate JOVIAL-to-Ada software re-engineering capability for avionics software.
- FY99 - Demonstrate low-cost capability to emulate computers with automated reconfiguration
- FY99 - Adapt commercial operating system and object request broker technology to support incremental avionics upgrades.
- FY00 - Complete development on a prototype automated real-time translator for binary-to-binary translation.
- FY00 - Demonstrate the incremental avionics upgrade approach with a significant avionics application.
- FY01 - Demonstrate completely reconfigurable weapon system simulation/test system eliminating the need for expensive, individual simulators.
- FY02 - Demonstrate techniques for modernization of complex avionics software systems.
- FY03 - Demonstrate advanced scaleable avionics architecture technology.
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Integrated Avionics

- FY97 - Design Integrated Sensor System (ISS) common RF modules, and initiate embedded control and application software design.
- FY97 Demonstrate ISS Infrastructure: RF/Digital Backplane, Resource Manager, Software, Photonic Networks
- FY98 - Demonstrate common modules, detection and avoidance algorithms, and integrated Ada software approach for fixed and rotary wing Special Operations low altitude penetrating platforms.
- FY98 - Demonstrate affordable COTS interoperatibility in the real-time avionics simulation environment of the avionics wind tunnel.
- FY98 - Demonstrate low cost in-flight mission training and rehearsal system for Special Operations infil/exfil aircraft.
- FY99 Finish ISS Demonstration, Transition to JSF/Retrofits.
- FY00 - Demonstrate reconfigurable, geographically distributed simulator environment capable of simultaneous, multiple scenario testing.
- FY00 - Demonstrate low-cost, integrated avonics for an entire avionics suite.
- FY01 Demonstrate Digital Radar Receiver
- FY02 - Transition a common RF and EO system approach for aging aircraft.

Information Fusion

- FY98 - Develop and implement information fusion testbed that will be a WL "Center" for information fusion evaluation competitions and demonstrations.
- FY99 - Demonstrate prototype, real-time data base management system with stored terrain, obstacle, feature, and "all source" threat data in a multilevel secure environment.
- FY99 - Demonstrate evidential tactical reasoning capability for combat aircraft.
- FY01 - Develop baseline offboard/onboard targeting management algorithms.
- FY02 - Development baseline algorithms and architecture for distributed detection and tracking of low-observable targets.

Avionics Displays

- FY98 - Develop two-fold increase in AMLCD optical efficiency and 15,000-hour MTBF; demonstrate a high definition front panel UTA mission operator display system.
- FY99 - Develop displays using non-glass substrates, including metal, ceramic, plastic; demonstrate 3-million pixel resolution for panoramic/immersive cockpit displays.
- FY00 - Develop high definition flexible display substrate for panoramic cockpit display system; demonstrate large area, single panel 4-6 million pixel panoramic cockpit display.
- FY01- Demonstrate FED flight instrument; demonstrate 20,000-hour MTBF.
- FY02- Develop true 3-D threat indicator.
- FY03- Demonstrate canopy display system.

THRUST #4: MILITARY UNIQUE ELECTRON DEVICES

USER NEEDS

Electron device technology has now established an unprecedented track record of successfully enhancing the superiority of Air Force weapons systems. The result of the DoD's three-decade investment in this technology is a pervasiveness which affects almost every aspect of the American culture. A rapidly growing consumer electronics market now demands the attention of industry. Furthermore, the promise of this lucrative market, combined with a shrinking DoD budget, is forcing many industrial partners to ignore the Air Force's requirement to maintain the superiority of its weapon systems. It is fair to state that total reliance on commercial, off-the-shelf (COTS) technology severely weakens the Air Force's technological advantage over an adversary. There are valid demands placed on electron device technology that have no place in the consumer electronics market. Therefore, the goal of any work in this thrust is to avoid the work supporting the consumer market, and focus instead on that niche we call "military unique electron devices." New, exciting, military unique technologies are continually emerging, and continued support and exploitation of these technologies is key to satisfying the following future warfighter needs:

- Continuous situational awareness
- Reliable radar for all weapons systems
- Real-time, low-power signal processing and information transfer
- Target recognition/location in adverse weather
- Multiwavelength IR countermeasures
- Electronics affordability (reliability, maintainability and supportability)
- Obsolete parts replacement
- Threat warning sensor enhancement
- Electronics integration for affordable multifunction radio frequency sensors

These technology needs are referenced in the following three Technical Planning Integrated Product Team Documents (TPIPTs):

- ASC: Air-to-Surface; Aerospace Control; Electronic Combat
- ESC: Surveillance/Recce
- SMC: Force Enhancement

The Electron Devices Thrust addresses these and other military unique warfighter needs with three functional areas: Microelectronics, Radio Frequency (RF) Components and Electro-Optical (EO) Devices. It resolutely directs its resources toward solutions that cannot be achieved with COTS technology. We work closely with Phillips and Rome Laboratories, as well as the Army, Navy, and other DoD organizations, such as the Under Secretary of Defence's (Acquisition & Technology) Advisory Group on Electron Devices, to avoid duplication of effort and make the most of the DoD's investment.

GOALS

Microelectronics - develops and transitions new device technology to address the need for affordable, higher throughput signal processing devices that must often withstand severe environments.

This area is focused primarily on developing:

- New device phenomena
- High speed, high resolution analog-to-digital converters (ADCs)
- High speed, low power digital technologies
- Improved packaging and interconnect
- Cost effective design and manufacturing methodology to achieve survivable, failure free electronics in future electronic systems

RF Components - research and development is concerned with satisfying the future requirements for airborne and space-based radar, communications, electronic warfare (EW), and smart weapons through the generation, control, propagation, and detection, of microwave and millimeter wave signals. The major emphasis is on developing:

- Solid state power amplifiers for phased array antennas needed in multifunction radar, EW, and communications systems
- Microwave and millimeter wave power modules for advanced radar and EW systems
- Affordable, small volume millimeter wave integrated circuits (ICs) for terminal guidance and communications applications
- Multifunction phased array component technologies, such as filters and multiplexers, for advanced radar/EW/communications systems

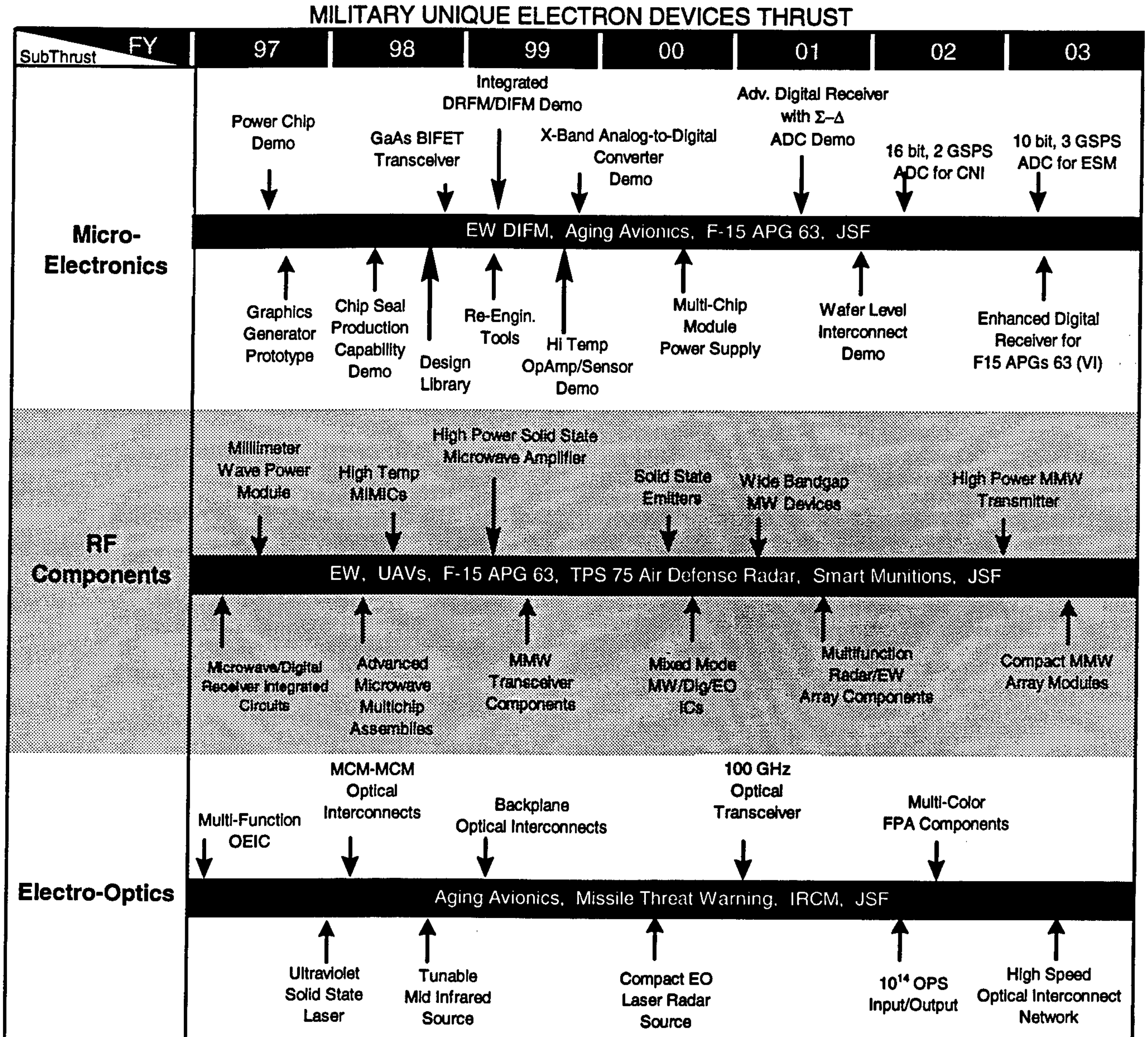

Figure 9. Military Unique Electron Devices Roadmap

- High-power, high-efficiency microwave/millimeter wave transmitters for airborne and space-based platforms
- Mixed-mode integrated circuits for compact radar and EW sensors
- High density packaging and interconnects for RF Mutli-Chip Modules (MCMs) and sensor subsystems

EO Devices - provides a device and component technology base that transitions basic materials and device research concepts into advanced development approaches for system prototypes. The approach is continually guided by such system needs as missile warning sensors, active and passive sensors for communications, laser radar, IR countermeasures (IRCM), weapon delivery and target tracking, recognition, and classification. The majority of the program is focused on:

- More complete spectral coverage
- More accurate, higher resolution sensor capabilities
- Optoelectronic/digital/microwave circuits to improve system performance and reduce cost
- Developing the infrastructure to facilitate compatible integration of optics and electronics
- Low power, 2-5 micrometer tunable laser for laser radar & IRCM

The devices, packaging and design tools realized within these three areas will continue to build upon the strong technology base ultimately responsible for high performance, reliable and affordable systems in the Air Force.

MAJOR ACCOMPLISHMENTS

Microelectronics: During FY96, key mixed-signal, GaAs BiFET (HBT/FET) components for a receiver/transmitter chipset were designed and are currently in the process of being demonstrated. Optimization of the baseline components will immediately follow. This receiver/transmitter chipset will enable miniaturization of Digital Instantaneous Frequency Measurers (DIFMs) and Digital RF Memories (DRFMs) in current EW systems.

During 4Q96, a program entitled "High Speed Circuits for Radar and EW" was initiated. The objective of this effort is to move the digital interface closer to the sensor/antenna in radar and EW receivers by developing three generations of InP Delta-Sigma modulators. The first design (0.18 GHz IF) has recently been completed and demonstration is anticipated for the 3Q97.

Investments in InP Analog to Digital Converter (ADC) technology now offers significant savings in retrofitting F-15 radars. New ADC technology, produced through the DARPA HBT pilot line, has allowed a new design of the APG 63(V)1 radar which replaces nine old boards with five new boards. The new ADCs enable a 90% increase in system reliability and significant performance growth. The Air Force will experience at least a 700% return on investment in this design when unit cost and lifecycle cost savings are considered. This new technology will also result in similar savings for each new APG-73 installed in the Navy's F-18 retrofit program.

In the area of wafer level coatings, the ChipSeal™ Inorganic Sealing Technologies Program has successfully completed coating over 100 wafers, comprising 10 different device types from 9 different semiconductor manufacturers, using the materials and processes developed in Phase I of the program. Device testing after applying and patterning ChipSeal™ coatings indicated that no statistically significant reduction in device yield occurred during ChipSeal™ processing. The 10 different device types will be used for various applications, including assembly of state-of-the-art digital and analog multi-chip modules, corrosion and impedance spectroscopy measurements, and plastic quad flat-pack encapsulation studies on assembly yield enhancement and accelerated stress testing to determine long term reliability.

Wright Laboratory has continued to work closely with DARPA on their packaging and interconnect efforts. These include efforts addressing MCM mixed-signal design, known good die, testing, aluminum nitride (AlN) packaging, integrated passives, and large area lithography. We are also working with Phillips Laboratory on a Single Layer Integrated Metallization Field Effect Transistor (SLIMFET) which promises to make radiation hardened GaAs available for space applications.

Successful results from the first two years of the Affordable Aluminum Nitride Packaging program has resulted in approval of third year funding for this Technology Reinvestment Project (TRP). The focus of the third year will be on demonstrating a qualified process by means of fabricating a multi-element T/R module assembly.

In the area of multi-chip power supplies, a working 30 MHz GaAs power switching HBT device has been demonstrated. Developments will now continue to achieve a 100 MHz HBT for inclusion in the "point of use" power converter which will provide approximately 10 Vdc at 2 amps for T/R module application

In design automation technology, a silicon compiler to automatically produce neural network integrated circuits was developed; thus cutting to a fraction the cost of creating these circuits which support automatic target recognition and sensor fusion processing. Some new design technology which supports the form, fit, and function cloning of legacy electronics was developed and is being used on an F-16 board re-design. It is expected that these tools will greatly cut the cost of replacing obsolete electronics with modern microelectronics. Some new candidates for industry standardization were presented this past year to the international standards organizations. The first was a language reference manual for an Analog and Mixed-Signal (analog and digital functions on the same circuit) Hardware Description Language which will foster communication between analog circuit designers and design tool vendors and allow the creation of automated analog and mixed-signal circuit design tools. The second was an intermediate data representation format for the industry standard Very High Speed Integrated Circuit Hardware Description Language (VHDL) which will allow VHDL tools

from multiple vendors to "plug and play" together and make it easier to design avionics. The third is the initial release of a public domain analyzer of VHDL descriptions that will be the standard for all academic VHDL-based design automation tool developments; thus cutting the cost of performing and improving the quality of automated microelectronics design research.

RF Components: In FY97, microwave power module (MPM) technology has been extended in frequency to realize 2-6 GHz 100 Watt 30% power added efficiency and 18-40 GHz 40 Watt modules. The MPM combines a compact travelling wave tube and wideband Monolithic Microwave Integrated Circuit (MMIC) amplifier with an integrated power converter in a compact assembly. These power amplifiers are used for advanced EW jammer and integrated avionic applications. They offer lower cost and smaller size than discrete component technology, and are well suited for UAV applications. In the area of high density microwave packaging, a fully functional four element "tile" based 8-10 GHz transmit/receive module has been demonstrated for the first time. Each element of the 2x2 tile delivers over 5 Watts output power with a 3 dB noise figure. The tile offers 40% size and weight savings over conventional "brick" style modules in a planar array and is an enabling technology for conformal radar arrays. In the millimeter wave range, an 80 mW, 20% power added efficiency MMIC chip based on indium phosphide technology has been demonstrated for operation at 94 GHz for missile seeker applications.

Heterojunction bipolar transistors are being developed in-house for achieving higher power amplifiers in even smaller packages, as well as for low phase noise oscillators. The output power density of these devices offers potential for an order of magnitude more power per unit area than is available from field effect transistors, at very high efficiencies and with very good amplifier linearity. Collaborative efforts are underway with 6 industrial organizations to delineate, understand and eliminate the failure mechanisms which limit the achievement of reliable, high power operation.

The Avionics Directorate, Electron Devices Division is the Air Force's lead organization for the DARPA sponsored Microwave and Analog Front End Technology (MAFET) Program. The MAFET program is developing the technologies required to extend the performance of radio frequency systems employing multichip assemblies (MCAs) for military radar, smart weapons, electronic countermeasures, secure communications and accurate combat identification. Air Force efforts are reducing the time and memory needed for large electromagnetic simulations required for accurate millimeter MCA design. Additional efforts are targeted at accurate on-wafer test of RF chips, and developing an independent merchant MCA foundry for a source of more affordable, low volume application-specific MIMIC chips.

A joint Technology Reinvestment Project (TRP) with DARPA to address microwave and millimeter wave wireless communications and intelligent vehicle highway systems was completed this year. The TRP effort developed MIMIC chip, design and packaging technology applicable to military dual-use applications including digital battlefield communications, RF tags (i.e., miniature location devices), and expendable jammers and decoys.

EO Devices: Vertical Cavity Surface Emitting Laser (VCSEL) materials growth and device processing techniques are being developed in an in-house effort under AFOSR funding to develop threshold-less lasers for chip to chip optical interconnects. A novel oxidization furnace has been developed which will confine the current through the device to be confined to an extremely small area, thus enabling lasers which operate with approximately a microampere of total current.

Initial growths of semiconductor ultraviolet detector structures in the gallium nitride/ aluminum gallium nitride (GaN/AlGaN) materials system have been demonstrated on substrate materials that show improvement over conventional sapphire substrate approaches. Also, initial design and modeling of a solid state readout-multiplexer array based on GaN/AlGaN charge coupled devices (CCDs) have been demonstrated.

Techniques for growing antimony based semiconductor structures for reproducible fabrication of optically pumped lasers for the 2 micrometer wavelength region for IRCM is proceeding in a collaborative effort with Phillips Laboratory. Under a New World Vistas program, similar techniques are being applied to make more reproducible and affordable laser structures at 785 nanometers wavelength for Ballistic Winds. Future plans call for developing diode lasers at 2 micrometers using antimony-based compounds similar to those now under development for Phillips Laboratory.

An optical link for backplane optical interconnects using passive polymers has been demonstrated that integrates electronics, lasers, multimode waveguides, and receivers using standard MCM and backplane lithography. The optical link operates at a data rate of 1 GHz. The interconnect density is 250 signal lines per board edge inch, or 5 times higher than that currently offered by electrical Z-Pack backplane connectors. A total insertion loss of -10.2 dB has been measured.

Advances in the development of non-linear optical materials, resulting from close collaboration with AA/ML, have led to higher power, extended mid-IR wavelength devices. Recent advances in periodically poled lithium niobate (PPLN) technology have significantly increased its utility for military applications. Last year the successful poling of a 1 mm thick PPLN crystal, and demonstration of PPLN diffusion bonding technology allow PPLN to be used in many new high energy per pulse applications. Additionally, the successful demonstration of an intracavity PPLN laser, leading to potentially higher conversion efficiencies, increases its attractiveness in many applications.

CHANGES FROM LAST YEAR

Microelectronics: Funding cuts have resulted in restructuring and descoping of the High Performance Integrated Microsensor program to develop navigational accelerometers. The transducer design will be completed in FY97 but will not be fabricated. The complementary Navy sensor program is undergoing review as a result of the Air Force's descoping of this effort. In addition, due to funding cuts the high temperature silicon carbide electronics program is being descoped but will commence in late FY97 using Propulsion Directorate funds to continue development of the Op-Amp which will be demonstrated in FY99.

Efforts will also begin to support the design of analog systems. Analog designs are among the high cost drivers for most avionics systems. There has been little change in analog design tools in over 10 years and there is no automated synthesis capability equivalent to that available to digital designers. With the industry close to obtaining a standard analog hardware description language and the availability of very powerful desktop computing technology, it is time to begin developing analog design automation technology.

Under the design automation activity, there has been a strong emphasis in increasing the design efficiency of Field Programmable Gate Arrays (FPGAs). FPGAs are exciting, relatively new, COTS integrated circuits which can have all of their internal logic (and therefore their computing function) reconfigured and optimized by the user while they reside in the avionic system. Engineering modifications can therefore be accomplished without remanufacturing the circuits and modules, and the same hardware can dynamically change its function while in the air -- thereby saving size, weight, and power. FPGAs are also ideal for reducing the cost of re-engineering obsolete avionics. There is new emphasis in: a) making the automatic design synthesis tools smarter, b) raising the level of abstraction at which the designer interacts with the tools, and c) reducing the amount of detail the designer needs to know about the microelectronic technology and its manufacturing processes.

RF Components: In FY97, 6.2 & 6.3A funds are being used to partially fund the AWACS broadband vacuum electronics power amplifier demonstration, continue work on miniature filters for radar/EW arrays, and demonstrate microwave/digital mixed-mode receivers and direct digital synthesizers for radar and EW applications.

EO Devices: DARPA funding of laser source work continues to be strong. Research plans call for the development of robust and tunable sources for a large variety of applications for use in the UV to the IR wavelengths. Two main areas of thrust are in the development of UV sources (lasers/light emitting diodes) and mid-IR sources (lasers). Although an area with exploitable new technology and validated user needs, Air Force budget cuts over the past year have forced the cancellation of a UV detector program.

MILESTONES

Microelectronics:

- 2Q98 - Demonstrate ChipSeal™ reliability of plastic encapsulated and bare die integrated circuits equal to hermetically sealed integrated circuits under highly accelerated test conditions.
- 2Q98 - Advanced InP HBT technology for 20 GSPS ADCs demonstrated.

• 3Q98 - 1.0 GHz Δ-Σ ADC for single down conversion receiver demonstrated.
• 4Q98 - GaAs BiFET integrated transceiver chip set demonstrated for EW DIFM/DRFM application.
• 4Q98 - Demonstrate power converter operation with T/R modules.
• 4Q98 - Complete a validation suite to insure that all Very High Speed Integrated Circuit Hardware Design Language (VHDL) simulators give the same results; Release computer-based VHDL training for SPOs and ALCs . Complete the full-function public domain VHDL analyzer.
• FY99 - 10 GHz Δ-Σ ADC for direct x-band receiver demonstrated.
• FY99 - Fabricate improved operational amplifier in silicon carbide for turbine engine control.
• FY99 - Demonstrate tools for high level design and optimization of Field Programmable Gate Arrays (FPGAs)
• FY00 - Initial versions of tools for automatic analog design synthesis will be released.
• FY01 - Demonstration of InP Δ-Σ ADC in JSF multi-mode radar prototype.
• FY03 - Demonstration of 10 bit, 3GSps ADC for ESM receivers.

RF Components:

• 2Q97 - Demonstrate first 300 watt output power SiC Static Induction Transistor operating 3 GHz with 45 % efficiency for air defense radar transmitters.
• 4Q97 Demonstrate a compact, very thin (~1 Inch) 64-element tile MCM sub-array operating at 8-10 GHz for airborne phased array radars.
• FY98 - Couple in-house work on MMIC material/device correlation and analysis with the DARPA/Tri-Service MAFET program to demonstrate enhanced chip performance and affordability.
• FY98 - Develop a robust, 20 Watt linear power amplifier that has 50% power added efficiency at 10 GHz.
• FY98 - Demonstrate membrane probe capable of measuring MMICs and Glass Microwave Integrated Circuits (GMICs) on wafers up to 26 GHz and up to 1300 I/O at a time on up to 12 inch wafers.
• FY00 - Develop solid state emitters based on wide bandgap semiconductors for use in vacuum tubes, displays and RF power sources.
• FY00 - Demonstrate 5 Watt output power, 35 GHz power amplifier for missile seeker compact transmitters.
• FY00 Demonstrate millimeter wave transceiver components, for radar and EW sensors.
• FY01 - Develop highly integrated mixed mode microwave/ digital/ optoelectronic components for radar, EW and communications applications.
• FY02 - Demonstrate advanced multichip assemblies for millimeter wave active aperture systems.

EO Devices:

• FY97 - Demonstrate GaN/AlGaN materials growth maturity as exhibited by controlled variability of the aluminum concentration in GaN to specify the cutoff wavelength, specifically as it applies to solar-blindness.
• FY98 - Develop the technology, and baseline, for higher sensitivity ultraviolet detection employing GaN/AlGaN PC (photoconductive) and PV (photovoltaic) detectors grown on nonconventional (non-sapphire) substrates.
• FY98 - Demonstrate bandwidth control of an optical parametric oscillator for improved functionality of solid-state laser radar systems.
• FY00 - Demonstrate multispectral infrared focal plane array capability.
• FY00 - Demonstrate MCM to MCM optical interconnect technology for digital radar applications.
• FY00 - Develop a robust, diode-pumped laser resonator source.
• FY01 - Demonstrate a set of UV GaN, AlGaN, and AlN point and imaging detectors
• FY03 - Develop integrated circuit optical interconnects

GLOSSARY

A

A/C	Aircraft
AAP	Advanced Avionics Processor
ACC	Air Combat Command
ADAMS	A Digital Avionics Methodology Schema
ADC	Analog-to-Digital Converters
ADV	Advanced
ADVISE	Avionics Data Visualization Integration System Environment
AF	Air Force
AFAE	Air Force Acquisition Executive
AFB	Air Force Base
AFIT	Air Force Institute of Technology
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFSOC	Air Force Special Operations Command
AIRST	Advanced Infrared Search and Track
ALC	Air Logistics Center
ALCAR	Advanced Low Cost Architecture Radar
AlGaN	Aluminum Gallium Nitride
AIN	Aluminum Nitrides
AMC	Air Mobility Command
AMDRFM	Advanced Monolithic Digital RF Memory
AMLCD	Active Matrix Liquid Crystal Display
AMMDE	Advanced Micro Machined Display Engine
AMRAAM	Advanced Medium Range Air-to-Air Missile
ASC	Aeronautical Systems Center
ASC/RA	Reconnaissance SPO
ASTAT	Affordable Sensor Technology for Aerial Targeting
ATD	Advanced Technology Demonstration
ATD/C	Automatic Target Detection/Cueing
ATIRCM	Advanced Threat IRCM
ATR	Automatic Target Recognition
AWACS	Airborne Warning and Control System

B

BAA	Broad Area Announcement
BDA	Bomb Damage Assessment
BiFET	Bipolar Field Effect Transistor
BIPS	Billion Instructions Per Second
BIST	Built-In-Self-Test
BMDO	Ballistic Missile Defense Organization
BTI	Briefing to Industry
BW	Ballistic Winds

C

C^2	Command and Control
C^2W	Command and Control Warfare
C^3	Communications, Command, and Control
C^3I	Communications, Command, and Control Intelligence
C^4I	Command, Control, Communications, Computers and Intelligence
CAE	Computer Aided Engineering
CAMIS	Computer Assisted Minimally Invasive Surgery
CC&D	Concealment, Camouflage & Deception
CCD	Charge Coupled Devices
CCM	Counter-countermeasure
CEE	Collaborative Engineering Environment
C-HFET	Complementary Heterostructure Field Effect Transistor
CLOAR	Common Low-Observable Auto-Router
CM	Countermeasure
CMOS	Complementary Metal Oxide Semiconductor
CNI	Communications, Navigation, and Identification
CoDE	Coherent Digital Exciter
CONOPS	CONcept of OPperations
COTS	Commercial Off-The-Shelf
CRDA	Cooperative R&D Agreements
CRT	Cathode Ray Tube

GLOSSARY

CW	Continuous Wave
D	
DAD	Distributed Architecture Decoy
DAMES	Defense Airborne Missile System
DARPA	Defense Advanced Research Project Agency
DARTS	Dynamic Avionics Real-Time Scheduling
dB	Decibel
dc	Direct Current
DEA	Data Exchange Agreement
DF	Direction Finding
DICE	Data Integration and Collection Environment
DIFM	Digital Instantaneous Frequency Measurement
DIRCM	Defensive IRCM
DIS	Distributed Interactive Simulation
DMD	Digital Micromirror Device
DoD	Department of Defense
DRFM	Digital RF Memory
DSO	Defensive System Operator
DTAP	Department of Defense Technology Area Plan
DTO	Defense Technology Objective
E	
E&MD	Engineering and Manufacturing Development
EA	Electronic Attack
EC	Electronic Combat
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ELINT	ELectronic INTelligence
EM	Electromechanical
EMD	Engineering Manufacturing Development
EO	Electro-Optical
EO-IR	Electro-Optical-Infrared
EP	Electronic Protection
ERASER	Enhanced Recognition and Sensing Radar
ES	Electronic Support
ESAI	Expanded Situation Awareness Insertion Program
ESC	Electronics System Center
EW	Electronic Warfare
F	
F^3R	Form, Fit, Function Retrofit
FED	Field Emissive Device
FET	Field Effect Transistor
FLIR	Forward-Looking Infrared
FOG	Fiber Optic Gyroscope
FOPEN	FOliage PENetration
FPA	Focal Plane Array
FPGA	Field Programmable Gated Array
FY	Fiscal Year
G	
GaAs	Gallium Arsenide
GAC	General Avionics Computer
GaN	Gallium Nitride
Gbps	Gigabytes per second
GHz	Gigahertz
GMIC	Glass Microwave Integrated Circuit
GP	Gas Plasma
GPS	Global Positioning System
H	
HBT	Heterojunction Bipolar Transistor
HQ	Headquarters
HQ AF	Headquarters Air Force
HRR	High Resolution Radar
Hz	Hertz
H/W	Hardware
I	
IC	Integrated Circuit
ICNIS	Integrated CNI Subsystem
ID	Identification

GLOSSARY

IDAL	Integrated Defense Avionics Laboratory
IDECM	Integrated Defensive ECM
IEEE	Institute for Electrical and Electronics Engineers
IESS	Integrated Electromagnetic System Simulator
IFSAR	Interferometric Synthetic Aperture Radar
InP	Indium Phosphide
INS	Inertial Navigation System
IR	Infrared
IR&D	Independent Research and Development
IRCM	Infrared Countermeasures
IRST	Infrared Search and Track
ISS	Integrated Sensor System
ITB	Integrated Test Bed
IW	Information Warfare

J-K

JAST	Joint Advanced Strikefighter Technology
JMSP	Joint Multi-Spectral Sensor Program
JOANNA	Joint Airborne Navigation and Attack
JR	Jam Resistance
JSF	Joint Strike Fighter
JSTARS	Joint Surveillance Target Attack Radar System
JWSTP	Joint Warfighting Science & Technology Plan
KHz	Kilohertz
KMOR	Keep Missile on the Rail

L

LANTIRN	Low Altitude Navigation and Targeting Infrared System for Night
LCC	Life Cycle Cost
LED	Light Emitting Diode
LIFE	Laser Infrared Flyout Experiment
LO	Low Observables
LPD	Low Probability of Detection
LPD/JR	Low Probability of Detection/Jam Resistant
LPI	Low Probability of Intercept
LSRET	Legacy Software Re-Engineering Technology
LWIR	Long Wavelength Infrared

M

MAFET	Microwave and Analog Front-End Technology Program
MAJCOM	Major Command
MAJIC	Monopulse Angle Jamming Integrated Countermeasures
MANPAD	MAN Portable Air Defense
MAP	Mission Area Plan
MBV	Model-Based Vision
MCA	Multichip Assembly
MCM	Multichip Module
MHz	Megahertz
MIMIC	Microwave/Millimeter Wave Integrated Circuit
MLD	Missile Launch Detector
MMC	Modular Mission Computer
MMIC	Monolithic Microwave Integrated Circuit
MOA	Memorandum of Agreement
MOSAIC	Modeling System for Advanced Investigation of Countermeasures
MOU	Memorandum of Understanding
MPM	Microwave Power Module
MPP	Modernization Planning Process
MSTAR	Moving and Stationary Target Acquisition and Recognition
MTBF	Mean Time Between Failure

N

NASA	National Aeronautics and Space Administration
NavTEL	Navigation Test Evaluation Laboratory
NCID	Non-Cooperative IDentification
NIMA	National Imagery and Mapping Agency
NRL	Naval Research Laboratory

GLOSSARY

O

OBATS	Off-Board Augmented Theater Surveillance
OBTEX	Off-Board Targeting Experiments
OC-ALC	Oklahoma City Air Logistics Center
OFP	Operational Flight Program
OLED	Organic Light Emitting Diode
OPO	Optical Parametric Oscillator
ORTA	Office of Research and Technology Applications
OSD	Office of Secretary of Defense
OSO	Offensive System Operator
OTD	Office of the Test Director

P

PC	Photoconductive
PCMCIA	Personal Computer Memory Card International Association
PE	Program Element
PGM	Precision Guided Munitions
PL	Phillips Laboratory
POD	Planar Optic Display
PLAID	Precision Location and Identification
PPLN	Periodically Poled Lithium Niobate
PV	Photovoltaic

R

R&D	Research and Development
RACE	Reconfigurable Avionics Computer Emulator
RAD	Random Agile Deinterleaver
RADCON	Radar Detection of Concealed Targets
RCS	Radar Cross-Section
RF	Radio Frequency
RFCM	Radio Frequency Countermeasure
RGB	Red-Green-Blue
RL	Rome Laboratory
RTIC	Real-Time Information in the Cockpit
RTOC	Real-Time Out of the Cockpit
RTSMP	Real-Time Symmetric Multiprocessor
RWR	Radar Warning Receiver

S

S&T	Science and Technology
S/W	Software
SA	Situation Awareness
SAB	Scientific Advisory Board
SAM	Surface to Air Missile
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
SAWS	Silent Attack Warning System
SBIR	Small Business Innovative Research
SCI	Scaleable Coherent Interface
SEAD	Suppression of Enemy Air Defense
SGMTI	Single Ground Moving Target Indicator
SHF	Super-High Frequency
SIGINT	SIGnal INTelligence
SID	Society for International Display
SLIMFET	Single Layer Integrated Metallization FET
SOF	Special Operations Forces
SPO	System Program Offices
SRR	System Requirements Review
STIG	Space Technology Interdependency Group

T

T/R	Transmit/Receive
TADIX	Tactical Data Information Exchange System
TAP	Technology Area Plan
TARA	Technology Area Review and Assessment
TEO	Technology Executive Officer
TESSA	TMD Eagle Smart Sensor ATR
TF/TA	Terrain Following/Terrain Avoidance
TMD	Theater Missile Defense

GLOSSARY

TMP	Technology Master Process
TPEW	Technology Panel for EW
TPIPT	Technical Planning Integrated Product Team
TRP	Technology Reinvestment Project
TTO	Technology Transition Officer
TWT	Traveling Wave Tube
U	
UAV	Unmanned Air Vehicle
UCAV	Uninhabited Combat Air Vehicle
UHF	Ultra-High Frequency
UHR	Ultra-High Resolution Radar
UHRR	Ultra-High Range Resolution Radar
URAV	Uninhabited Reconnaissance Air Vehicle
USAF	United States Air Force
USSOCOM	United States Special Operations Command
UV	Ultraviolet
V-W	
VCSEL	Vertical Cavity Surface Emitting Laser
Vdc	Volts dc
VHDL	VHSIC Hardware Design Language
VHF	Very-High Frequency
VHSIC	Very High Speed Integrated Circuit
VLSI	Very Large Scale Integration
WAVES	Waveform and Vector Exchange Specifications
WL	Wright Laboratory
WPAFB	Wright-Patterson Air Force Base
WR-ALC	Warner Robins Air Logistics Center
WSMR	White Sands Missile Range
WTN	Wright Technology Network
WWW	World Wide Web

INDEX

TAP SUBTHRUSTS